5. SUMMARY OF OBSERVATIONS AND FINDINGS

The following sections summarize the results of the experimental portion of this investigation. Results will be presented in four primary sections. First, the inspector physical/psychological characteristics collected through the SRQs and vision tests will be summarized. Second, results from the Routine Inspection tasks (Tasks A, B, C, D, E, and G) will be presented. Third, results from the two In-Depth Inspections (Tasks F and H) will be presented. Finally, results from the State-dependent tasks (Tasks I and J) will be presented.

5.1. INSPECTOR CHARACTERISTICS

As was mentioned previously, inspectors were asked to complete two written SRQs and to take three vision tests. The results from these will be presented in the following three sections.

5.1.1. SRQ Results

The following presents the results from each question on the SRQs. Results will be presented in a question-by-question format similar to that used in Chapter 3. The questions will be repeated exactly as they were presented on the SRQs. The motivation behind each question will then briefly be discussed, followed by a summary of the data collected. Where appropriate, commentary may also be included to supplement the basic data presentation. Some of the questions were common to both SRQs. In general, inspectors gave consistent responses to these questions on both SRQs. In light of this, results from common questions will only be presented from responses on the first SRQ.

SRQ1. **Age:** ___________
Height: ___________
Weight: ___________

Question SRQ1 was asked to simply collect some physical data about each inspector. Table 19 summarizes inspector responses to question SRQ1.

Table 19. Age, height, and weight characteristics of inspectors.

	Average	Standard Deviation	Minimum	Maximum
Age, years	40.5	6.5	28	54
Height, m	1.82	0.076	1.68	2.01
Weight, kg	87.0	13.7	68.2	134.1

SRQ2. How would you describe your general physical condition?

Poor	Below Average	Average	Above Average	Superior
1	**2**	**3**	**4**	**5**

The goal of this question was to establish a pseudo-quantitative measure of each inspector's physical condition. The average for this question was a 3.4, with a standard deviation of 0.61. Figure 25 shows the distribution of the responses.

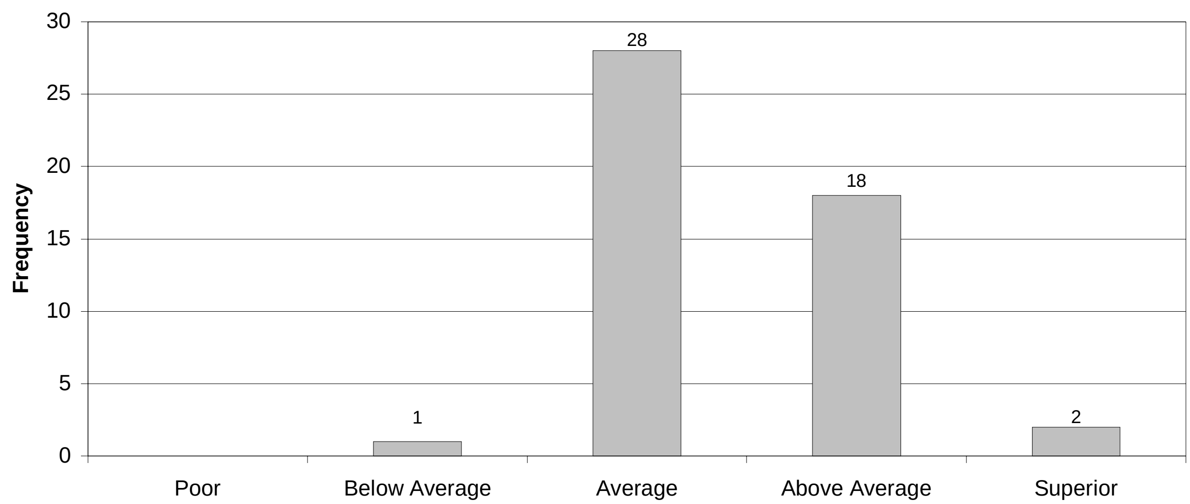


Figure 25. Distribution of inspector-reported general physical condition.

SRQ3. Do you currently have any orthopedic ailments (e.g., bad knees, bad back)?
Yes No

If so, list:________________________________

It was envisioned that an inspector with orthopedic ailments may not be able to perform some of the physically demanding aspects of a bridge inspection. Eighteen inspectors indicated that they had some type of orthopedic ailment. These could generally be classified as bad knees (6), bad shoulders (4), or a bad back (13).

SRQ4. Are you currently experiencing any temporary physical ailments (e.g., flu, head cold, etc.)?
Yes No

If so, list:______________________________

The goal for this question was to ascertain if any inspectors were suffering temporary physical ailments during their participation in the study. Six inspectors indicated that they were experiencing, or just getting over, a temporary physical ailment. The most commonly listed physical ailments were allergies (3) and influenza (3).

SRQ5. How would you describe your general mental condition?

Poor	Below Average	Average	Above Average	Superior
1	**2**	**3**	**4**	**5**

Similar to question SRQ2, question SRQ5 was developed to get a measure of the inspector's overall mental condition. Although tools exist to measure general mental condition, time constraints did not allow such a thorough assessment. The average answer to this question was a 3.7, with a standard deviation of 0.58. Figure 26 illustrates the distribution of inspector responses.

SRQ6. Are you currently experiencing additional stress due to personal problems (e.g., death in family, etc.)?
Yes No

Similar to question SRQ4, question SRQ6 was developed to determine if "out of the ordinary" stress might influence VI. Five inspectors indicated that they were experiencing some type of additional stress. Due to the personal nature of this question, information about the source of the stress was not requested.

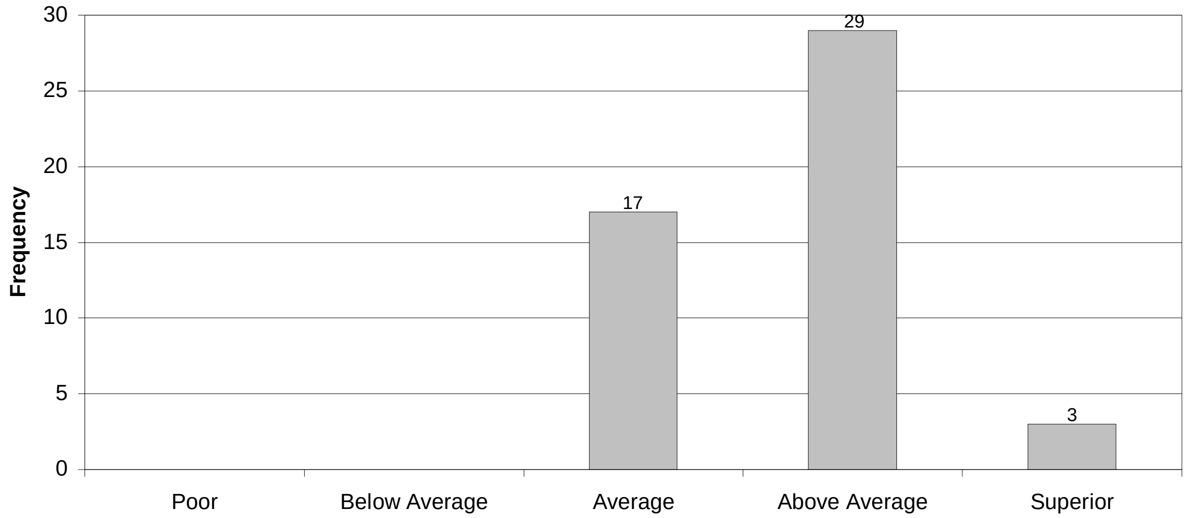


Figure 26. Distribution of inspector-reported general mental condition.

SRQ7. Overall today, how do you feel?

Poor	Below Average	Average	Above Average	Superior
1	**2**	**3**	**4**	**5**

To supplement the information gathered in questions SRQ1 through SRQ6, question SRQ7 gave inspectors the chance to quantify how they were generally feeling. The average response to question SRQ7 was a 3.5, with a standard deviation of 0.65. Figure 27 illustrates the distribution of the responses.

SRQ8. During an average bridge inspection, do you ever feel so tired or winded that you have to work slower or temporarily stop working?

Never	Very Rarely	Sometimes	Often	Almost Always
1	**2**	**3**	**4**	**5**

If so, under what conditions and how often: ______________________________
____

This question was asked to give a measure of the inspector's physical conditioning. The average response to question SRQ8 was 1.9 (standard deviation of 0.56). The most common conditions cited for working slower were on hot/humid days or when the inspector needed to navigate very rugged terrain. Figure 28 illustrates the quantitative distribution of the answers to question SRQ8.

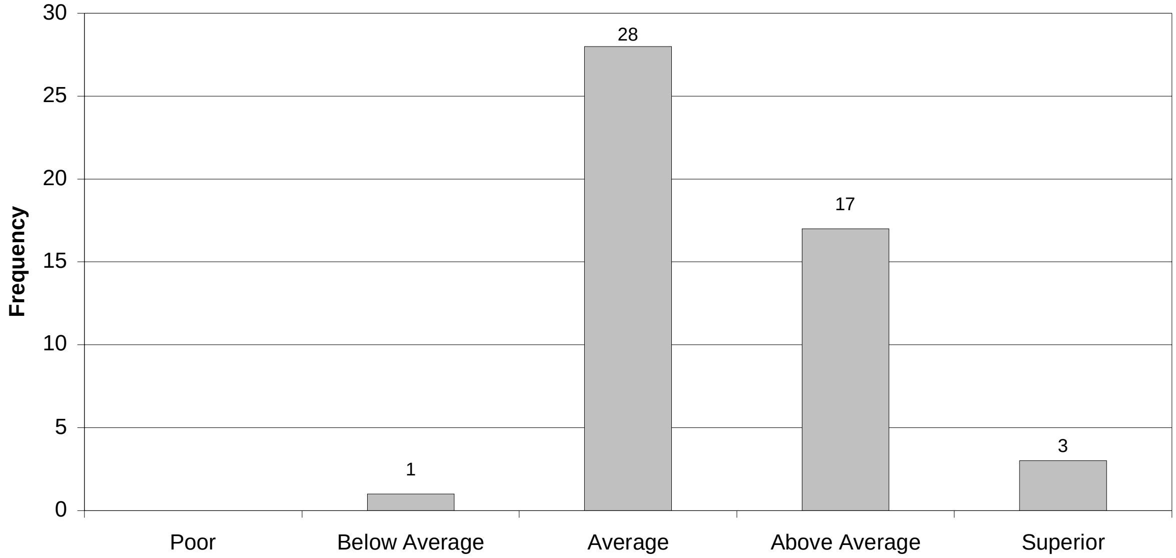


Figure 27. Distribution of inspector-reported overall condition.

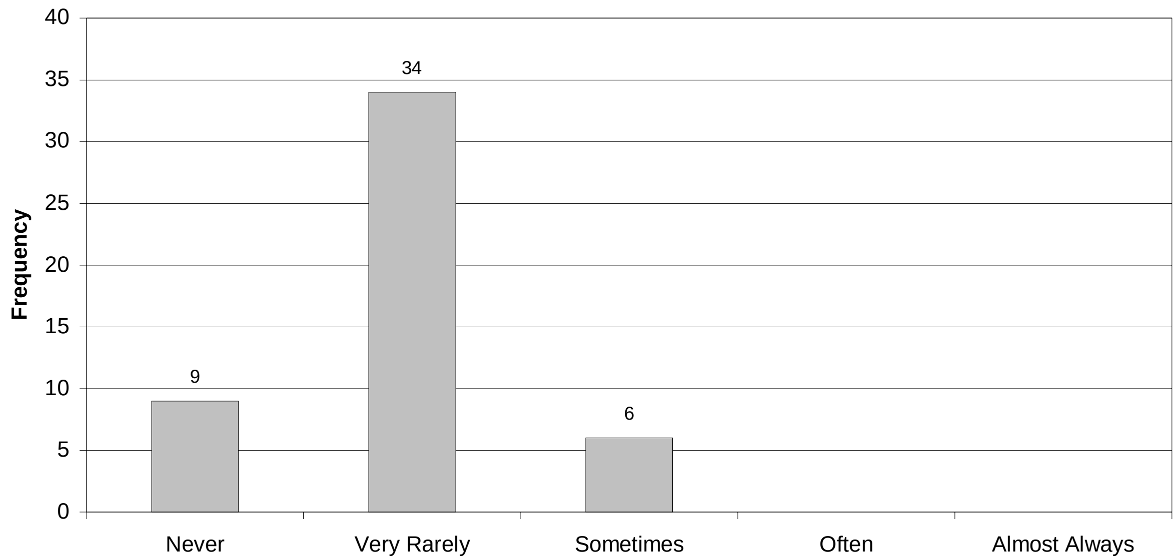


Figure 28. Distribution of how often inspectors get tired/winded during work.

SRQ9. Do you feel your work as a bridge inspector is important to public safety?

Not at all	Slightly Important	Important	Very Important	Essential
1	**2**	**3**	**4**	**5**

There were two motivating factors behind this question. First, this question could be used to gauge job satisfaction and, second, to determine if inspectors thought bridge inspection had a positive social impact. The average response to this question was a 4.6, with a standard deviation of 0.54. This indicates that, overall, inspectors feel their work is important to maintaining public safety. Figure 29 shows the frequency distribution for question SRQ9.

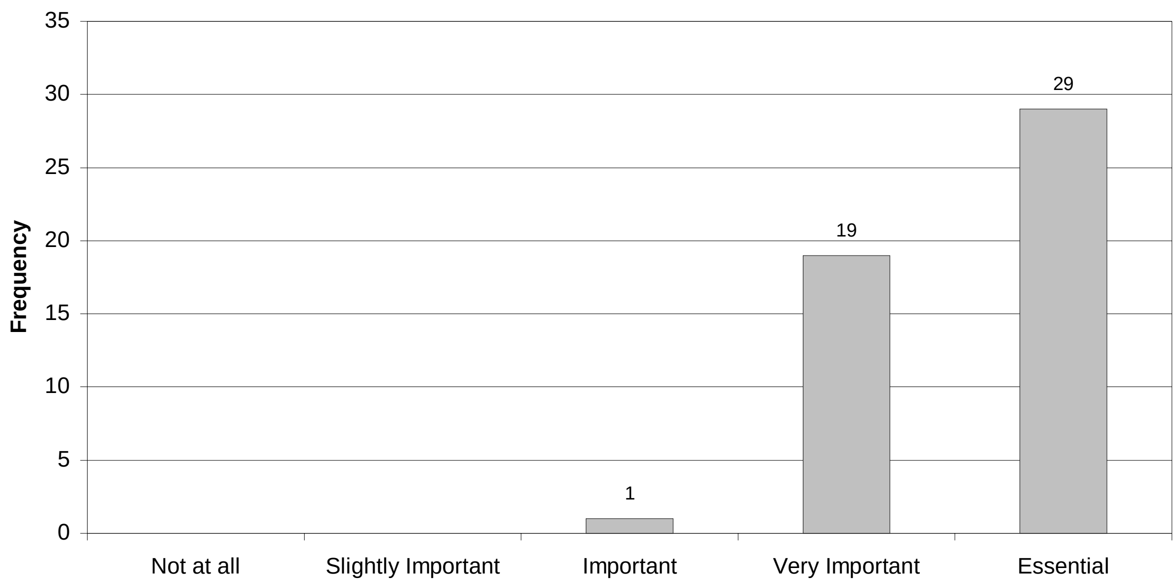


Figure 29. Distribution of perception of importance of work.

SRQ10. Do you ever assess the importance to public safety of the inspection that you are performing?
Yes No

Similar to question SRQ9, this question was asked to see if inspectors considered public safety while they were completing an inspection. Only 45 of 48 responding inspectors answered yes to this question. Although this indicates that many inspectors are completing their inspections with the goal of ensuring the safety of the public, it also indicates that some inspectors may have some other motivation. Unfortunately, the question format did not allow inspectors to elaborate on their answers and therefore additional information is not available.

SRQ11. **In general, how would you describe your level of mental focus over an entire bridge inspection?**

Poor	Slightly Unfocused	Average	Somewhat Focused	Very Focused
1	2	3	4	5

The goal of this question was to determine if performing a bridge inspection is interesting enough to hold an inspector's attention. The average inspector indicated that they were between "somewhat focused" and "very focused" (average of 4.4) while they were completing an inspection. Figure 30 illustrates the distribution of the responses.

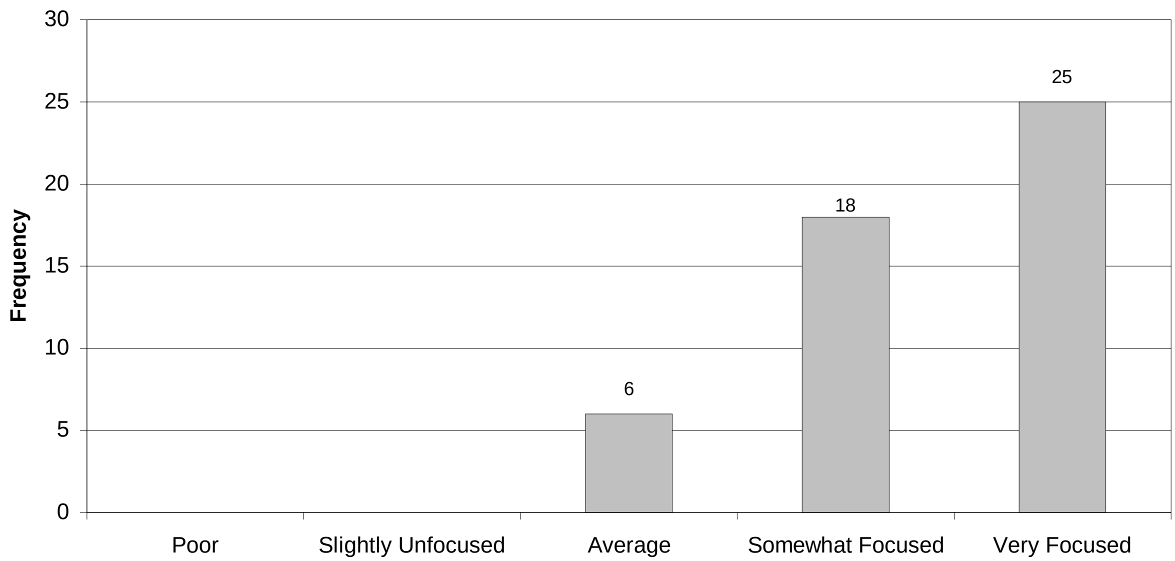


Figure 30. Level of focus during bridge inspections.

SRQ12. **How interesting is your work as a bridge inspector?**

Very Boring	Boring	Average	Somewhat Interesting	Very Interesting
1	2	3	4	5

Question SRQ12 was asked to supplement and to reinforce the answers to question SRQ11. The average was 4.5 (standard deviation of 0.58), indicating that most inspectors thought that their daily work was interesting. Figure 31 shows the distribution of the responses.

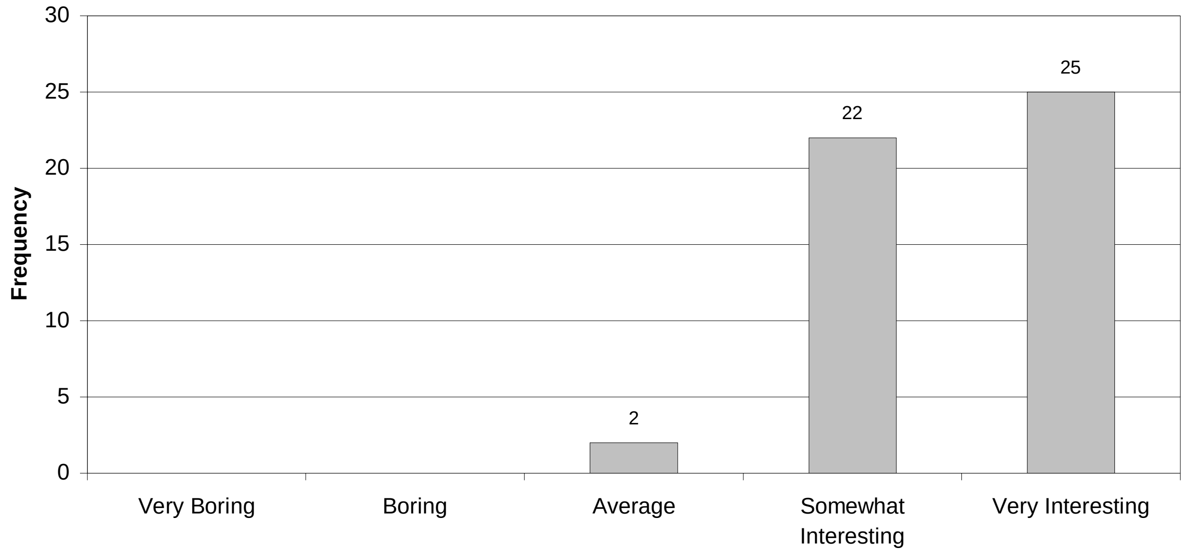


Figure 31. Distribution of inspector interest level in their work.

SRQ13. Imagine the following situation:

You are inspecting the superstructure of a steel girder/concrete deck bridge. The bridge is 60 ft high and the only means of access to the girders is from a snooper truck and the wind is gusting to 20 mph.

How fearful of the working height do you feel you would be?

Very Fearful	Somewhat Fearful	Mostly Fearless	No Fear
1	**2**	**3**	**4**

By proposing the hypothetical situation, it was envisioned that question SRQ13 would give insight into an inspector's fear of heights. The average response to question SRQ13 was approximately a 3 (Mostly Fearless), indicating that most inspectors are not bothered by modest working heights. As can be seen from figure 32, no inspector answered question SRQ13 with a 1. However, as will be discussed later, one inspector refused to use the 18.3-m boom lift necessary to complete Task H.

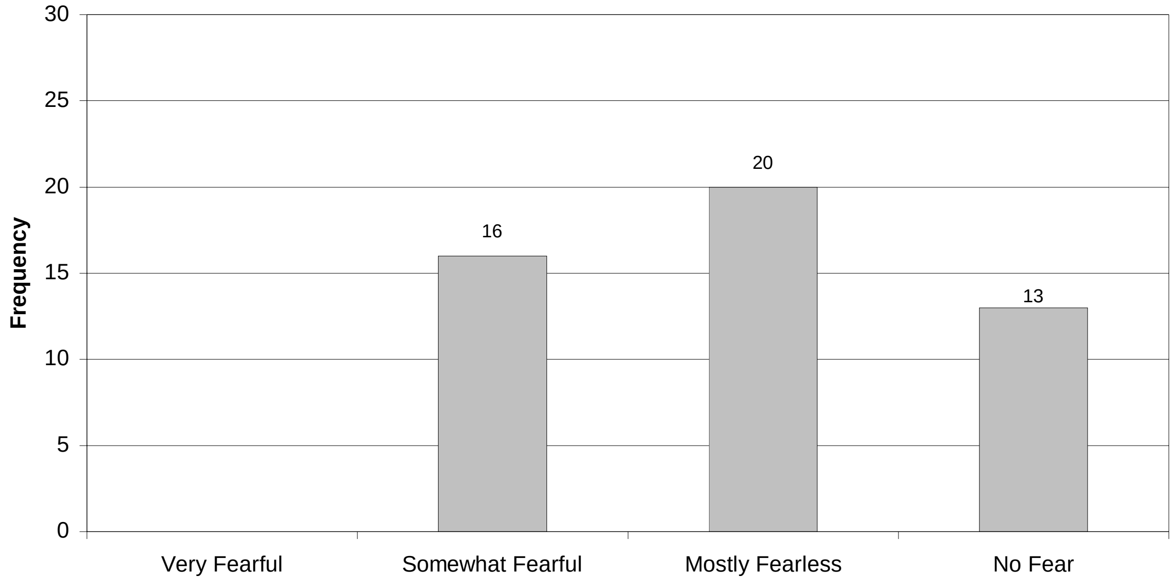


Figure 32. Distribution of reported fear of heights.

SRQ14. Imagine the following situation:

You are inspecting the interior of a 150-ft-long prestressed concrete box girder. The only light source is your flashlight. Traffic on the bridge continues uninterrupted and you can feel every passing vehicle.

How fearful of working in this enclosed space would you be?

Very Fearful	Somewhat Fearful	Mostly Fearless	No Fear
1	**2**	**3**	**4**

Similar to question SRQ13, this hypothetical scenario was presented with the goal of determining if inspectors might be afraid of working in enclosed spaces. With an average response of 3.1, it appears that most inspectors are generally not afraid of working in enclosed spaces. The distribution of the responses is shown in figure 33.

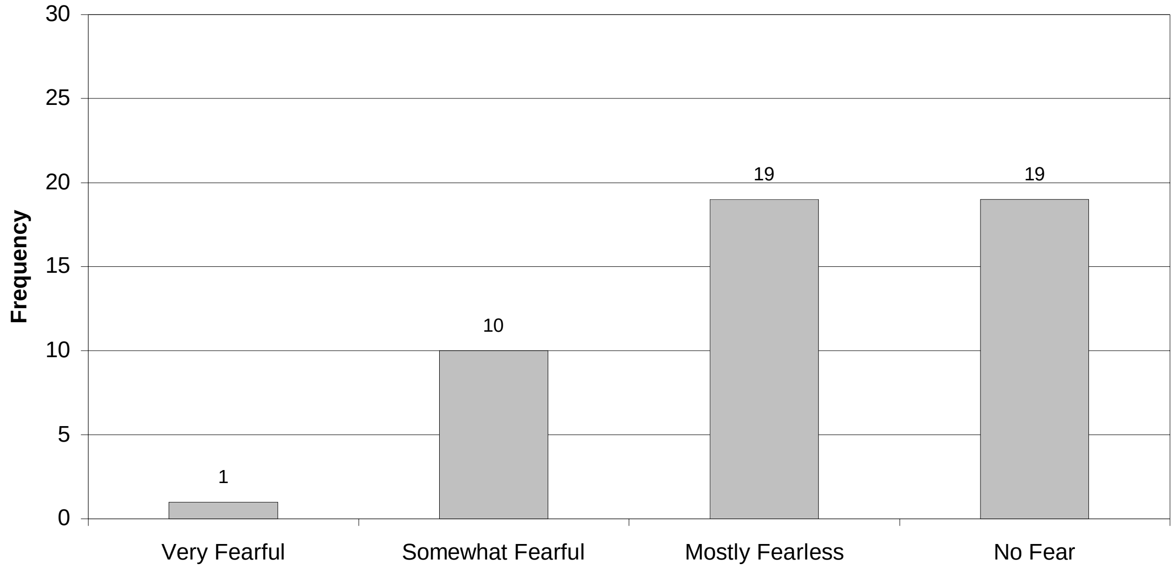


Figure 33. Inspector-reported fear of enclosed spaces.

SRQ15. Imagine the following situations:

You are completing an in-depth inspection of a major two-lane divided highway bridge. Only one lane can be closed at a time. Most of your time is spent kneeling at deck level to inspect the deck.

How fearful of the vehicular traffic do you feel you would be?

Very Fearful	Somewhat Fearful	Mostly Fearless	No Fear
1	**2**	**3**	**4**

The goal of this hypothetical situation was to ascertain if inspectors were afraid of being struck by vehicular traffic. Of the three scenarios presented in questions SRQ13 through SRQ15, inspectors indicated the greatest fear of traffic. The distribution of responses indicates that the traffic present during an inspection may have some influence on how inspections are completed. The distribution of the responses is shown in figure 34.

SRQ16. Have you ever been involved in an accident where you as a pedestrian were struck by a moving vehicle?
Yes No

To help interpret answers to question SRQ15, question SRQ16 sought to provide a reason for high fear levels. One inspector did report having been struck by a moving vehicle.

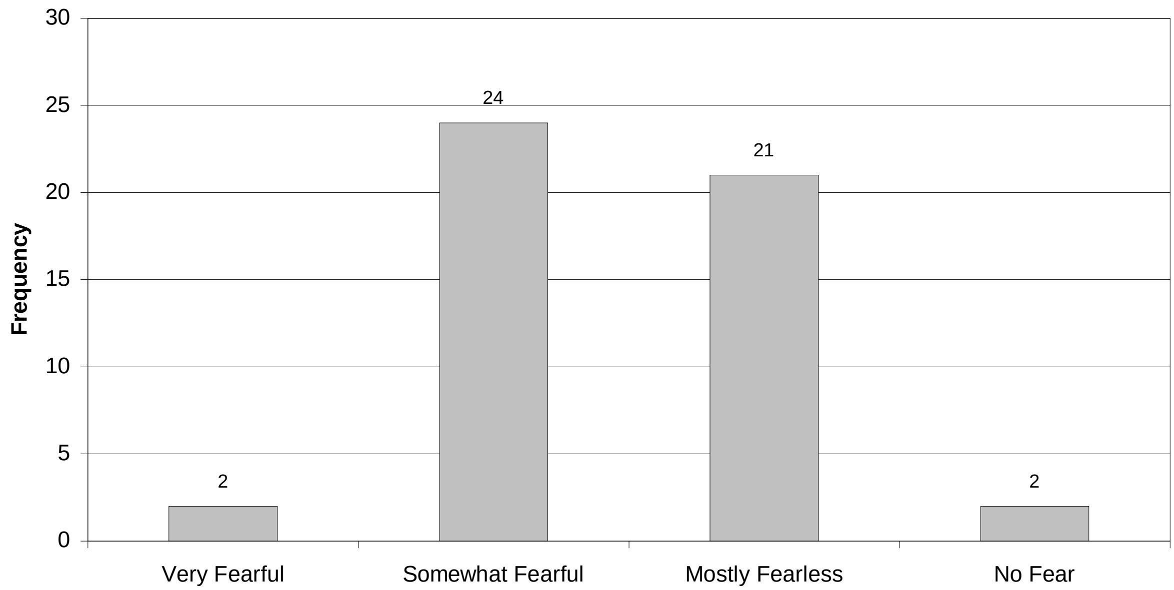


Figure 34. Inspector fear of vehicular traffic.

SRQ17. Have you ever been involved in an accident where you fell from typical bridge inspection working heights?
Yes No

This question was asked to help interpret the fear of heights levels determined from question SRQ13. Three inspectors indicated that they had fallen from a typical bridge inspection height. These particular inspectors indicated that they were either "somewhat fearful" or "mostly fearless" of heights in question SRQ13, indicating a low influence upon their current fear of heights.

SRQ18. What is the highest educational level that you have completed?

_____	**Some High School**			
_____	**High School Degree or equivalent**			
_____	**Some Trade School**			
_____	**Trade School Degree**			
_____	**Some College**			
_____	**Associate's Degree**	***Choose one***	***CE Technology***	***Other***
_____	**Bachelor's Degree**	***Choose one***	***Civil Engineering***	***Other***
_____	**Some Graduate Work**	***Choose one***	***Civil Engineering***	***Other***
_____	**Master's Degree**	***Choose one***	***Civil Engineering***	***Other***
_____	**Terminal Degree (e.g., Ph.D.)**	***Choose one***	***Civil Engineering***	***Other***
_____	**Other: __________________**			

There are many types of training thought to possibly have an influence on VI reliability. Question SRQ18 was developed to assess just one of these: general education level. Table 20 summarizes the response rate for each education level. This table shows that most inspectors have had some general education beyond high school and that many have completed a tertiary degree. However, less than half had obtained a bachelor's degree or higher.

Table 20. General Education Level.

Education Level	Number of Inspectors
Some High School	0
High School Degree or equivalent	10
Some Trade School	2
Trade School Degree	0
Some College	9
Associate's Degree	
CE Technology	3
Other	7
Bachelor's Degree	
Civil Engineering	12
Other	4
Some Graduate Work	
Civil Engineering	1
Other	0
Master's Degree	
Civil Engineering	1
Other	0
Terminal Degree	
Civil Engineering	0
Other	0
Other	0

SRQ19. What specific type of training have you had in bridge inspection? ***(you may check more than one)***

State Training
_____ In-house State-run bridge inspection training program.
_____ 'Apprentice' training on the job by experienced inspectors.
_____ Other: _________________

FHWA Training

_____ Bridge Inspector’s Training Course Part I – Engineering Concepts for Bridge Inspectors (NHI #13054)
_____ Bridge Inspector’s Training Course Part II – Safety Inspection of In-Service Bridges (NHI #13055)
_____ Inspection of Fracture-Critical Bridge Members Training Course
_____ Bridge Inspectors Training Course Refresher Training
_____ Nondestructive Testing Methods for Steel Bridges
_____ Culvert Design (NHI #13056)
_____ Other: _________________

Other: ____

____

In addition to general education, specific training in the area of bridge inspection may also influence VI reliability. Question SRQ19 was asked to determine the level of specific bridge inspection training courses that inspectors had completed. Thirty-seven inspectors indicated that they had completed some type of a State-run bridge inspection program and 32 inspectors indicated that they had received “apprentice”-type training from experienced inspectors. Ten inspectors indicated some type of “other” State training. Typical write-in answers included courses on scour, load rating, and the use of laptop computers. One inspector listed the Internet as a source of training.

Twenty-eight inspectors indicated that they had completed the Bridge Inspector’s Training Course Part I, while 35 indicated that they had completed Part II. This percentage is consistent with the results of the State-of-the-Practice survey presented previously. Recall that more than 95 percent of the States require the Bridge Inspector’s Training Course for team leaders and 79 percent of the States require it for other team members. It should, however, be pointed out that no distinction was made in the State-of-the-Practice survey between Parts I and II of the Bridge Inspector’s Training Course. Thirty-five inspectors indicated that they had completed the course on the inspection of fracture-critical members. Only 21 inspectors had completed the refresher course, while 25 had completed the training course on the use of NDT for steel bridges. Eleven inspectors indicated that they had completed the FHWA training course on culvert design and six inspectors listed some type of “Other” FHWA training. The most common write-in answer, regardless of the source of the training, was training on scour. Some inspectors indicated training in underwater inspections, paint and coatings, and historic bridges.

SRQ20. How many years of experience do you have in bridge inspection? ______

SRQ21. How many years of experience do you have in highway structures? _____

SRQ22. Have you ever worked as an inspector in another industry (e.g., aircraft, nuclear power, etc.)?
Yes No

Questions SRQ20 through SRQ22 were asked to determine how much experience the inspectors had and where that experience was obtained. The average inspector had just over 10 years of experience in bridge inspection (standard deviation of 6.1 years) and approximately 11.5 years of experience in the general area of highway structures (standard deviation of 7.6 years). The minimum experience that any inspector indicated was under 1 year and the maximum was 26 years in bridge inspection and 32 years in highway structures. The distribution of the answers to question SRQ20 is shown in figure 35. Eleven of the participating inspectors also indicated that they had been an inspector in another industry.

Figure 35. Distribution of inspector experience in bridge inspection.

SRQ23. How many more years do you expect to be performing bridge inspection before you move to another job or retire? __________

It was envisioned that inspectors who were nearing the end of their bridge inspection careers might perform a less thorough inspection. This could result from being close to retirement, having so much experience that inspections become mundane, or from a lack of job satisfaction and plans to change positions. The average inspector indicated that they anticipated working as a bridge inspector for approximately 11 additional years. One inspector anticipated working as a bridge inspector for less than a year, while another anticipated 30 more years inspecting bridges.

SRQ24. Is your organization's bridge inspection philosophy more similar to a) or b)?

_____ a) Provide an adequate inspection with the goal being to comply with NBIS.

_____ b) Provide a thorough inspection with the goal being to find all defects.

In order to establish each State's general philosophy with regard to bridge inspection, question SRQ24 provided two distinct philosophies. Fifteen inspectors indicated that their organization's bridge inspection philosophy was more similar to (a), while 32 indicated (b). Of note, 10 States had one inspector indicate (a), while the other inspector from that State indicated (b), seemingly contradicting one another.

SRQ25. How do you mentally prepare to complete a typical bridge inspection? ***(you may check more than one)***

_____ Study previous inspection reports for the particular bridge.

_____ Study cases of similar bridges for help in determining probable places to look for defects.

_____ Mentally recall similar bridges you have inspected.

_____ No preparation.

Proper preparation for an inspection may lead to more efficient and accurate inspections. Question SRQ25 was asked to ascertain what types of preparation inspectors typically complete. Forty-four inspectors indicated that they would review previous inspection reports, 12 indicated that they study similar bridges, and 39 indicated that they think back to similar bridges they have inspected. Three inspectors indicated no preparation, which may be due to a lack of preparation time caused by a limited inspection season.

SRQ26. In general, do your supervisors: (check only one)

_____ a) Provide you with a detailed checklist of items to inspect while at the bridge site?

_____ b) Provide loose guidelines for the inspection but leave the exact process up to you?

_____ c) Allow you to inspect the bridge using solely your own techniques, skills, and knowledge of the bridge inspection process?

Determining how inspectors generally approach an inspection was the goal of question SRQ26. Responses were fairly well distributed among the three choices. Thirteen inspectors indicated (a), while 16 and 20 indicated (b) and (c), respectively. Clearly, various States have different levels of administrative control placed on the inspectors.

SRQ27. How would you describe your relationship with your direct superior?

Very Poor	Poor	Average	Good	Very Good
1	2	3	4	5

The relationship between inspectors and their supervisor could have implications on VI reliability. Quantifying the quality of this relationship was the goal of question SRQ27. In general, inspectors indicated a "good" to "very good" relationship with their superiors (average of 4.3, standard deviation of 0.66). Although not entirely indicative of job satisfaction, this is one aspect of their jobs with which inspectors appear to be satisfied. Figure 36 shows the distribution of inspector responses to question SRQ27.

SRQ28. Do you feel that management feels that the work you do is important?

Not at all	Slightly Important	Important	Very Important	Essential
1	2	3	4	5

The perception of being appreciated is a significant motivator for many employees. This was the information sought through question SRQ28. Inspectors generally perceive that management feels bridge inspection is very important, but not essential (average of 3.9, standard deviation of 0.93). This fact can be clearly seen in figure 37. It can also be seen from figure 37 that more than 10 percent of the inspectors perceive that management feels their work is only slightly important.

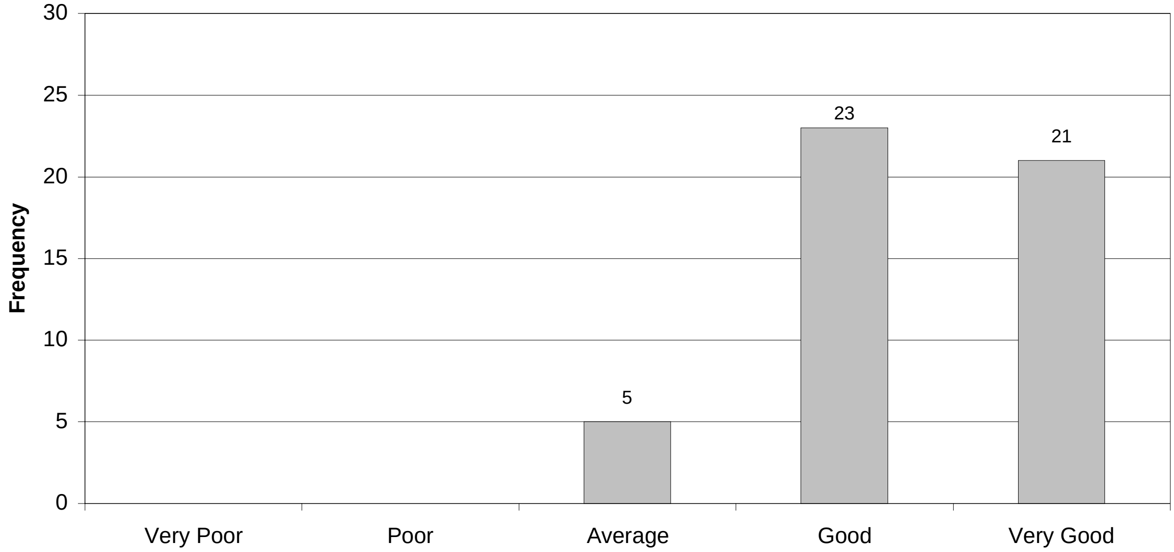


Figure 36. Quality of inspector relationship with direct superior.

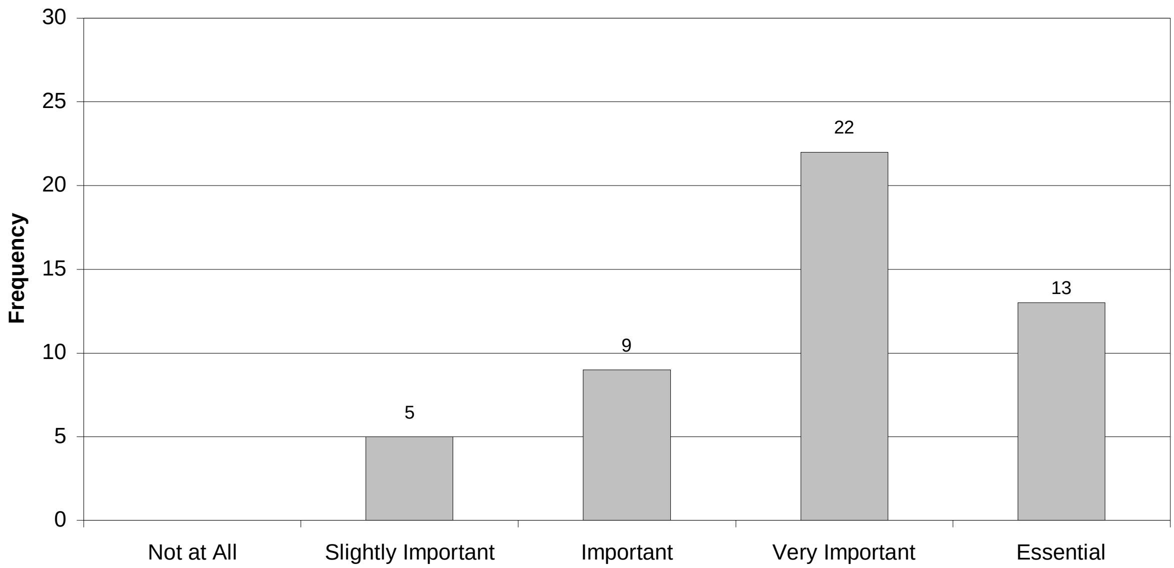


Figure 37. Inspector perception of the importance of inspection to management.

SRQ29. Within your duties for the State DOT, do you perform any work other than bridge inspection (i.e., construction inspection, etc.)? If so, what percentage of your time is spent at each activity?

Activity: Bridge Inspection % of time: __________
Activity: ___________________________________ % of time: __________
Activity: ___________________________________ % of time: __________
Activity: ___________________________________ % of time: __________

Bridge inspectors often have other duties in addition to bridge inspection. The goal of question SRQ29 was to determine how much time was actually devoted to bridge inspection and where other time might be allocated. On average, inspectors indicated that more than 80 percent of their time was spent on bridge inspection. The most common write-in activity was construction inspection. Also, one inspector indicated that approximately 20 percent of his time was spent on bridge inspection, while the remaining 80 percent was generally reserved for administrative duties and coordination with inspection contractors.

SRQ30. Given the following two definitions:

- **Routine Inspection—Routine Inspections are regularly scheduled inspections completed to determine the physical and functional condition of a bridge and to identify changes from the last inspection. Further, Routine Inspections serve to ensure that a bridge continues to satisfy all applicable serviceability requirements. Routine Inspections are also commonly known as NBI inspections.**
- **In-Depth Inspection—In-Depth Inspections are close-up, hands-on inspections of one or more bridge members in order to identify deficiencies not normally detectable during Routine Inspections.**

What percentage of your inspection duties could be classified as Routine Inspections?

____

What percentage of your inspection duties could be classified as In-Depth Inspections?

____

Assessing the split of time spent on Routine and In-Depth Inspections was the goal of question SRQ30. Inspectors indicated that approximately 65 percent of their inspections were Routine Inspections and 35 percent were In-Depth Inspections. However, the responses yielded a standard deviation of approximately 30 percent, indicating a fairly wide distribution of responses. In fact, inspectors indicated a range of Routine Inspection percentages from as little as 20 percent to as much as 99 percent. It should be pointed out that individual States may use different definitions than the ones presented above. These differences may have resulted in some inconsistent responses.

SRQ31. For the following hypothetical bridge, how many people would make up a field inspection team (excluding traffic control personnel), and how much time (in man-hours) would be budgeted?

Twenty-year-old, two-span bridge carrying two-lane road (medium ADT) over a small creek; maximum height above the creek is 20 ft.

Superstructure: Steel, four-girder superstructure (rolled shapes); welded flange cover plates; concrete deck.

Substructure: Concrete abutments, a single three-column concrete pier (with pier cap) out of the normal watercourse.

People: __________
Man-hours: __________

This question was repeated from the State-of-the-Practice survey with the goal of determining how inspectors' answers differed from State answers. Inspectors indicated that from one to seven people would be required (average of 2.3) and that the inspection would require between 0.5 man-hours and 28 man-hours (average of 5.3). The range of responses is indicative of the different inspection approaches used in different States. In comparison, responses from the State-of-the-Practice survey indicated a range of personnel from one to four (average of 2.0) with a time budget range from 0.5 to 16 man-hours (average of 4.8).

SRQ32. Estimate the percentage of bridge inspections completed with a registered Professional Engineer (PE) on-site. ***(circle one)***
0-20 20-40 40-60 60-80 80-100

Similar to question SRQ31, question SRQ32 was repeated from the State-of-the-Practice survey with a similar goal. Twenty-nine inspectors indicated 0 to 20 percent and 12 inspectors indicated 80 to 100 percent. This indicates that most States either use PEs nearly all of the time or very rarely use them. The remaining eight responses were fairly well distributed along the 20 to 80 range. These on-site percentages are similar to those obtained from the State-of-the-Practice survey. Recall that nearly 50 percent of the States indicated that a PE was on site for less than 20 percent of the inspections, while 25 percent indicated that a PE was on site for more than 60 percent of the inspections. Figure 38 shows the distribution of the responses.

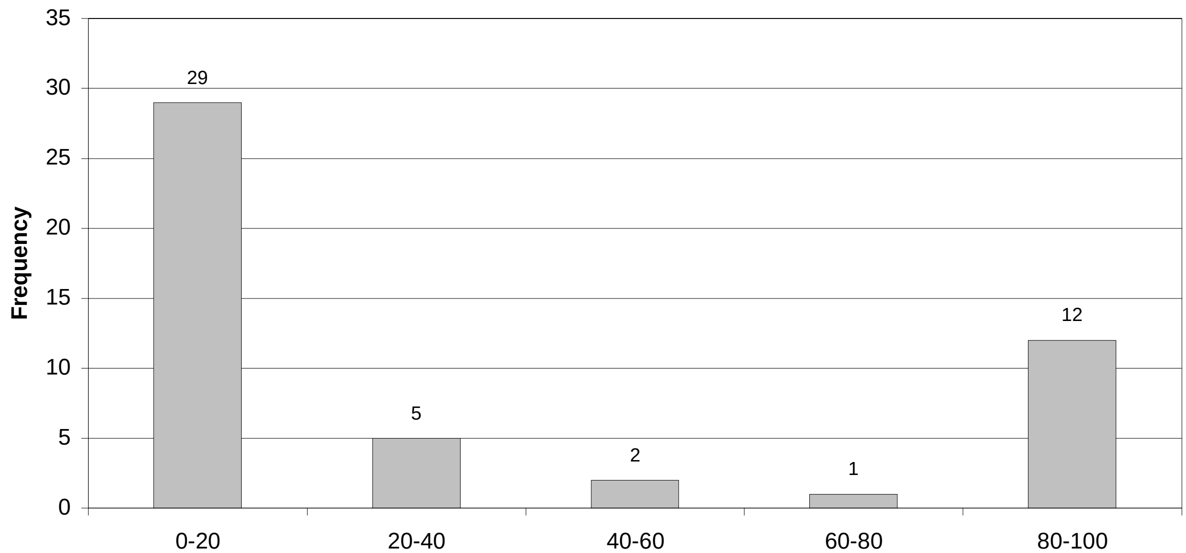


Figure 38. On-site percentage of PE indicated by inspectors.

After the conclusion of the field portion of the study, inspectors deemed likely to be registered PEs were asked a follow-up question. This question was asked to determine how many participants were registered. Of the 49 inspectors that participated, 7 were registered PEs.

SRQ33. Do you currently take any of the following substances?

Bilberry
Viagra
B vitamin complex

Yes No

Studies in other industries have shown that these substances may temporarily affect color vision. The goal with this question was to provide data for correlation with color vision deficiencies. Only three inspectors indicated that they were currently taking any of these substances. Of these three inspectors, color vision testing indicated a possible color vision deficiency for one of these inspectors.

SRQ34. In comparison to other bridge inspectors, how would you classify yourself based on your past performance?

Poor	Below average	Average	Above average	Excellent
1	**2**	**3**	**4**	**5**

Interestingly, the average answer to question SRQ34 was 3.6 (standard deviation of 0.76). The most common response was that the inspectors who participated in the study thought that they were an above average inspector. Figure 39 shows the distribution of inspector responses. The figure clearly shows that none of the inspectors thought they were below average or poor. It seems unlikely that an inspector would rate himself as "poor" or "below average" and, therefore, the answers to this question are probably artificially skewed to the right.

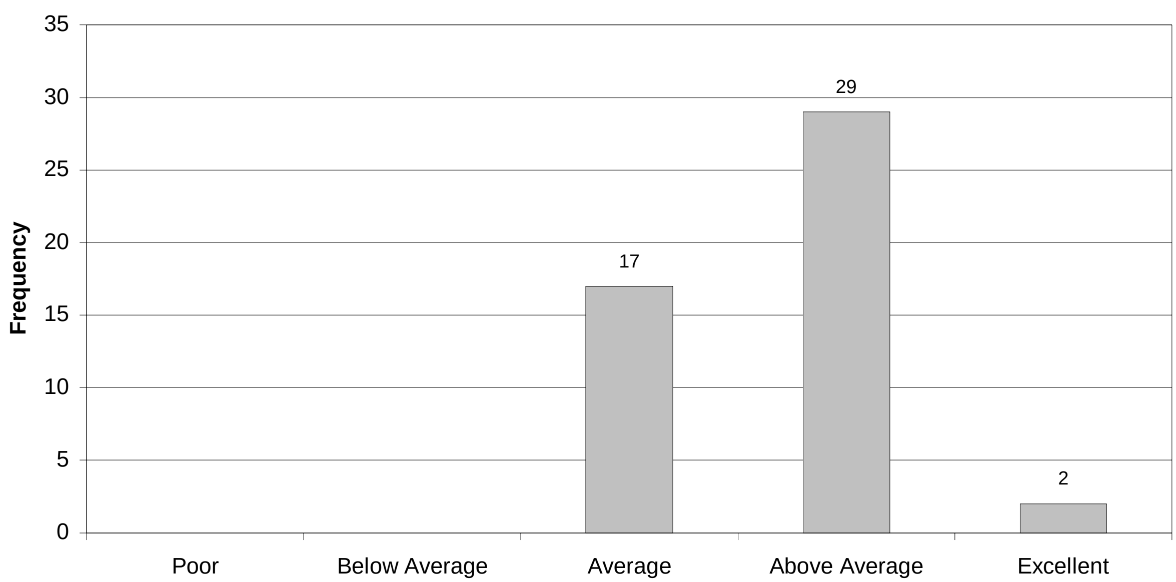


Figure 39. Inspector self-appraisal in comparison with other bridge inspectors.

SRQ35. If it was under your control, how do you think that bridge inspections could be improved?

____

____

____

Many times, the people most affected by administrative decisions are not directly involved in making those decisions. This question gave the inspectors a medium to provide suggestions for improving bridge inspection. Although a wide variety of write-in answers were given, they could generally be grouped into six broad categories. Two of the general categories focus on the number of bridge inspections each inspector must complete: more time per inspection and more inspectors/staff. In addition, some inspectors indicated that they would like more training and that an increase in uniformity in the rating system would increase inspection accuracy. The final two categories are directly related to the equipment the inspectors use: electronic data collection/modern field laptop computers and better access equipment.

SRQ36. Have you ever seen a bridge failure in person?
Yes No

If yes, please describe:

____
____
____

Firsthand experience with a bridge failure may have some impact on the care exercised during an inspection. Approximately half of the bridge inspectors had seen a bridge failure in person. The types of bridges that were described ranged from small pedestrian bridges to higher volume roadways. In the interest of maintaining anonymity, specific failures will not be discussed.

SRQ37. What time zone do you normally work in? _______________

The goal of this question was to assess whether jet lag influenced inspection performance. Twenty-seven of the inspectors normally work in the Eastern time zone, 12 in the Central time zone, four in the Mountain time zone, and six in the Pacific time zone. Note that this is a relatively even distribution when one considers the number of States in each time zone.

SRQ38. Approximately how many bridges do you inspect each year? _______________

The goal of this question was to quantify yearly bridge inspection experience. The average participating inspector indicated that they completed a total of 380 bridge inspections each year. The minimum that an inspector indicated was 50, while the maximum was 1,000. It should be pointed out that this question yielded a standard deviation of 245, indicating a wide distribution in the number of inspections completed.

SRQ39. Briefly describe how you became a bridge inspector.

____
____
____

Inspectors who became bridge inspectors by chance or by simply being moved into the position may not have the motivation to do as good of a job as those who sought out bridge inspection careers. Therefore, question SRQ39 asked inspectors to describe how they came to be an inspector. The most common answers to question SRQ39 were that they were either transferred from other areas in the DOT (14) or simply applied for the position in response to a job announcement (22). Two inspectors indicated that they were in the bridge inspection unit as part of a position "rotation" plan.

SRQ40. Within your organization, how important do you feel bridge inspection is?

Not Important	Slightly Important	Average	Somewhat Important	Very Important
1	2	3	4	5

Similar to some previous questions, question SRQ40 was developed to assess the importance of the work. Overall, inspectors felt that bridge inspection was between "somewhat important" and "very important" (average of 4.5) within their organization. This question differs from question SRQ28 where the inspectors indicated their perception of management's view of the importance of bridge inspection. Figure 40 summarizes the distribution of the responses.

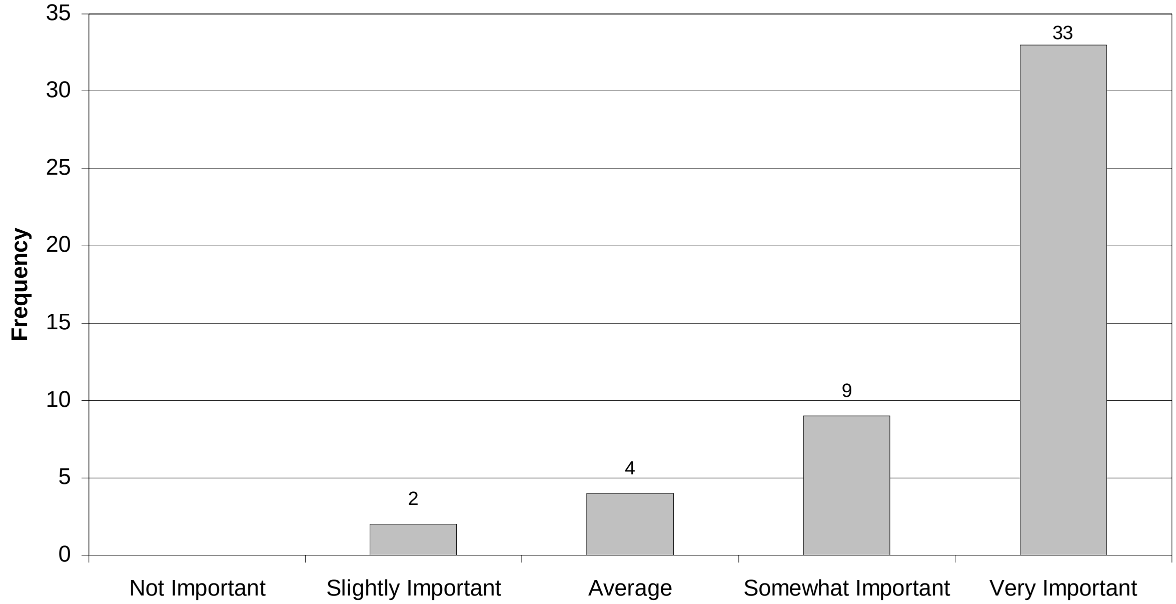


Figure 40. Inspector perception of bridge inspection within their organization.

5.1.2. Exit SRQ Results

As was mentioned previously, two SRQs were administered. The results from the initial SRQ were presented above. Questions ESRQ1 through ESRQ21 (out of 24) on the exit SRQ were identical to some of the questions on the initial SRQ. In general, inspectors gave the same answers to both questionnaires (e.g., question SRQ8: initial SRQ average was 1.94, exit SRQ average was 1.98). However, there were three questions on the exit SRQ not given on the initial SRQ that related to the inspectors' general perception of their participation in the study. The following summarizes the results of these three questions.

ESRQ22. Did you enjoy participating in these inspection tasks?
Yes No

This question was asked to determine if the inspector enjoyed participating in the study. Of the 46 responding inspectors, only 3 indicated that they did not enjoy completing the tasks.

ESRQ23. Do you feel that the observers did a good job?
Yes No

In order to ascertain if the inspectors thought that the observers did a good job, question ESRQ23 was asked. Only 1 of the 46 responding inspectors indicated that the observers did not do a good job. This indicates that, in general, the observers were cordial and tried to make a conscious effort to make the experience a pleasant one.

ESRQ24. On a scale from 1 to 10, what rating would you give the observers (1 = poor, 10 = excellent)?

____

Similar to question ESRQ23, question ESRQ24 was asked to gauge the inspectors' impression of the observers. The average response was an 8.2 (standard deviation of 1.2). The distribution of the responses is shown in figure 41.

5.1.3. Vision Test Results

The following summarizes the results of the three vision tests described previously. These vision tests were administered to assess three types of vision thought to influence VI.

5.1.3.1. NEAR AND DISTANCE VISUAL ACUITY

In general, inspectors had what could be considered "normal" near and distance visual acuity. Recall that inspectors were allowed to use any corrective lenses ordinarily used. However, there

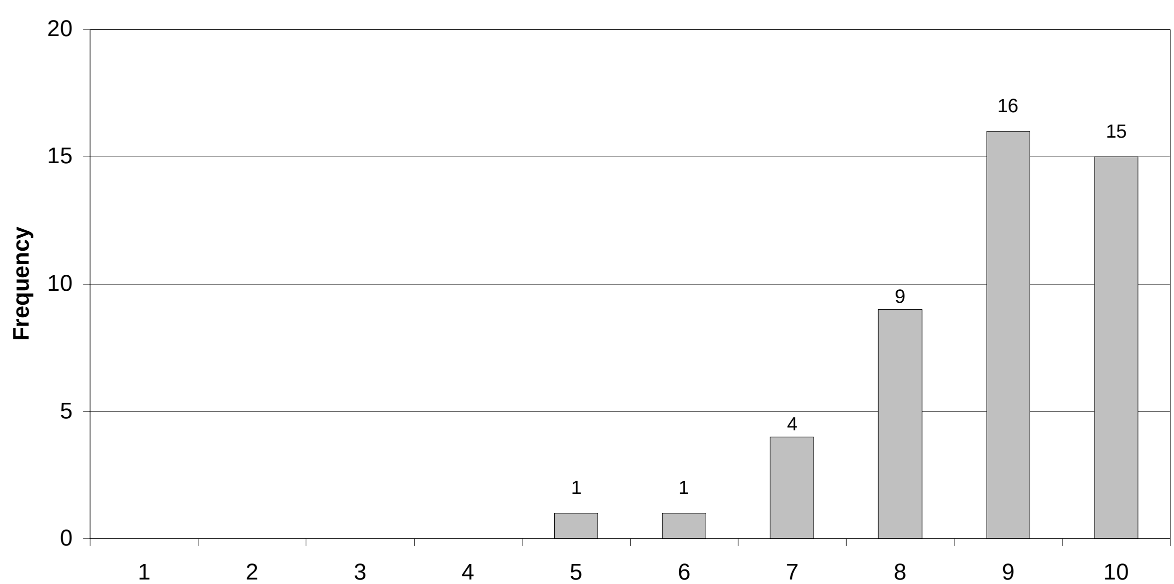


Figure 41. Distribution of inspector rating of observers.

was enough variation in the vision test results to be able to say that inspector vision is not necessarily 20/20.   In two cases, an inspector had very poor visual acuity (i.e., 20/160 or worse) in one eye. However, those two inspectors had better than 20/20 vision (both near and distance) in the other eye. The distribution of near and distance visual acuity is shown in figures 42 and 43, respectively.

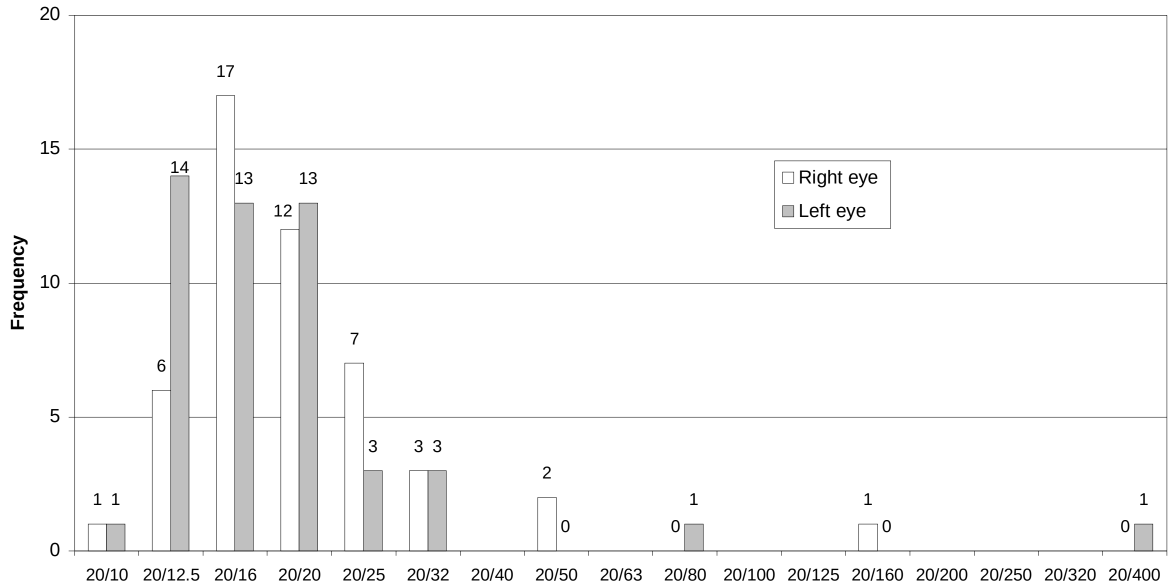


Figure 42. Distribution of near visual acuity.

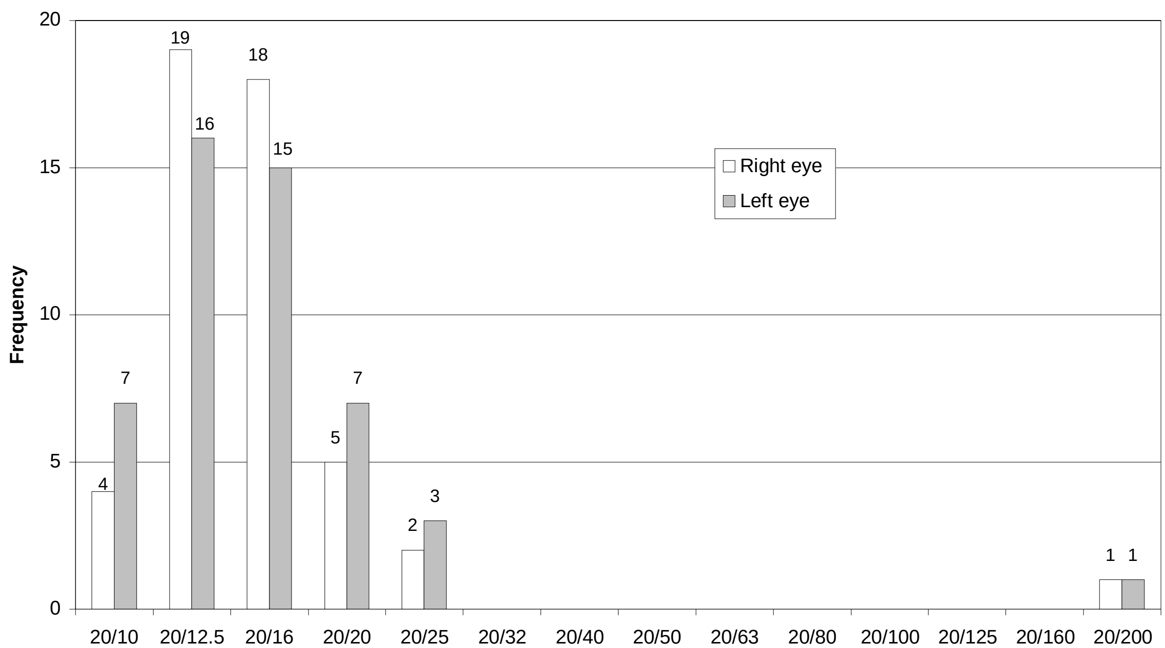


Figure 43. Distribution of distance visual acuity.

5.1.3.2. COLOR VISION

Approximately 10 percent of the general population exhibits some form of color vision deficiency. Consistent with this, the results of the color vision tests administered for this study indicated that 5 of 49 inspectors showed signs of a color vision deficiency. Of these five inspectors, two showed signs of Protan (i.e., red) color vision deficiency, one showed signs of Deutan (i.e., green) color vision deficiency, one showed signs of Tritan (i.e., blue) color vision deficiency, and one showed signs of all three types of color vision deficiencies.

5.1.4. Summary

Based on the responses to the SRQ questions and the results of the vision testing, it appears that the participating sample of bridge inspectors are, in general, representative of the population of bridge inspectors. However, it should be noted that although States were asked to send a "more" experienced inspector and a "less" experienced inspector, it is possible that some States may have sent two "more" experienced inspectors, skewing the sample.

5.2. ROUTINE INSPECTION RESULTS

The following sections present results from Tasks A, B, C, D, E, and G. These tasks are Routine Inspection tasks that typically resulted in three pieces of data. First, the three primary elements of each bridge were assigned Condition Ratings. Second, secondary bridge elements were also assessed and given Condition Ratings. Finally, to supplement the Condition Ratings, inspectors typically generated hand-written notes. During Task D, inspectors were also asked to provide visual documentation of their findings to supplement the Condition Ratings and notes. Results from the data collected during the Routine Inspection tasks are presented in the following sections. There are five primary subsections: a description of Routine Inspection and the inspection process; statistical analysis of the primary element Condition Ratings, including an assessment of the relationship of human and environmental factors; analysis of the photographs generated during Task D; analysis of inspection notes; and general statistical analysis of secondary element Condition Ratings.

5.2.1. Description of Routine Inspection

Before presenting the results of the Routine Inspection tasks, the following discussion presents the previously given definition of Routine Inspection used in this study. The *Manual for Condition Evaluation of Bridges, 1994* defines "Routine Inspection" as follows:[3]

> "Routine Inspections are regularly scheduled inspections consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from "Initial" or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.
>
> The Routine Inspection must fully satisfy the requirements of the National Bridge Inspection Standards with respect to maximum inspection frequency, the updating of Structure Inventory and Appraisal data and the qualifications of the inspection personnel. These inspections are generally conducted from the deck, ground and/or water levels, and from permanent work platforms and walkways, if present. Inspection of underwater portions of the substructure is limited to observations during low-flow periods and/or probing for signs of undermining. Special equipment, rigging, or staging, is necessary for Routine Inspection in circumstances where its use provides for the only practical means of access to areas of the structure being monitored.
>
> The areas of the structure to be closely monitored are those determined by previous inspections and/or load rating calculations to be critical to load-carrying capacity. In-Depth Inspection of the areas being monitored should be performed in accordance with Article 3.2.4. If additional close-up, hands-on inspection of other areas is found necessary during the inspection, then an In-Depth Inspection of those areas should also be performed in accordance with Article 3.2.4.
>
> The results of a Routine Inspection should be fully documented with appropriate photographs and a written report that includes any recommendations for maintenance or repair and for scheduling of follow-up In-Depth Inspections if necessary. The load

capacity should be re-evaluated to the extent that changed structural conditions would affect any previously recorded ratings."

In general, the Routine Inspection tasks completed as part of this study were administered and completed according to this definition. One notable deviation from this standard definition was the identification of changes from initial or previously recorded conditions. For these tasks, inspectors were not provided with previously recorded inspection information, thus ensuring that each inspector was recording their estimation of the bridge conditions and not simply relying on the accuracy of previously completed inspections. Another deviation from the standard definition occurred in the level of access allowed during some tasks. Specifically, there were safety constraints that prevented the inspectors from gaining full access to some bridges (e.g., use of ladders was prohibited completely for one task (Task C) and limited on another (Task E), and access to the deck was restricted on a third (Task G)).

5.2.2. Routine Inspection Process

The following summarizes how inspectors approached and completed the Routine Inspection tasks. In addition, the conditions under which they were completed and the inspectors' perceptions of the inspections are also presented. Data for this discussion comes from three previously described sources – the pre-task questionnaires, the firsthand observations, and the post-task questionnaires.

5.2.2.1. TASK A

Task A is the Routine Inspection of Bridge B521, an in-service, single span, through-girder bridge. Inspectors were allowed 40 min to complete the inspection with an average time of 38 min (standard deviation of 6 min) and a minimum and maximum completion time of 23 min and 50 min, respectively. Figure 44 shows the frequency distribution of completion times.

Figure 45 and table 21 summarize the pre-task question results in which inspectors provided quantitative responses. From this table, it can be seen that, on average, it had been slightly more than half a year since each inspector had last inspected a bridge of a similar type. Note that three

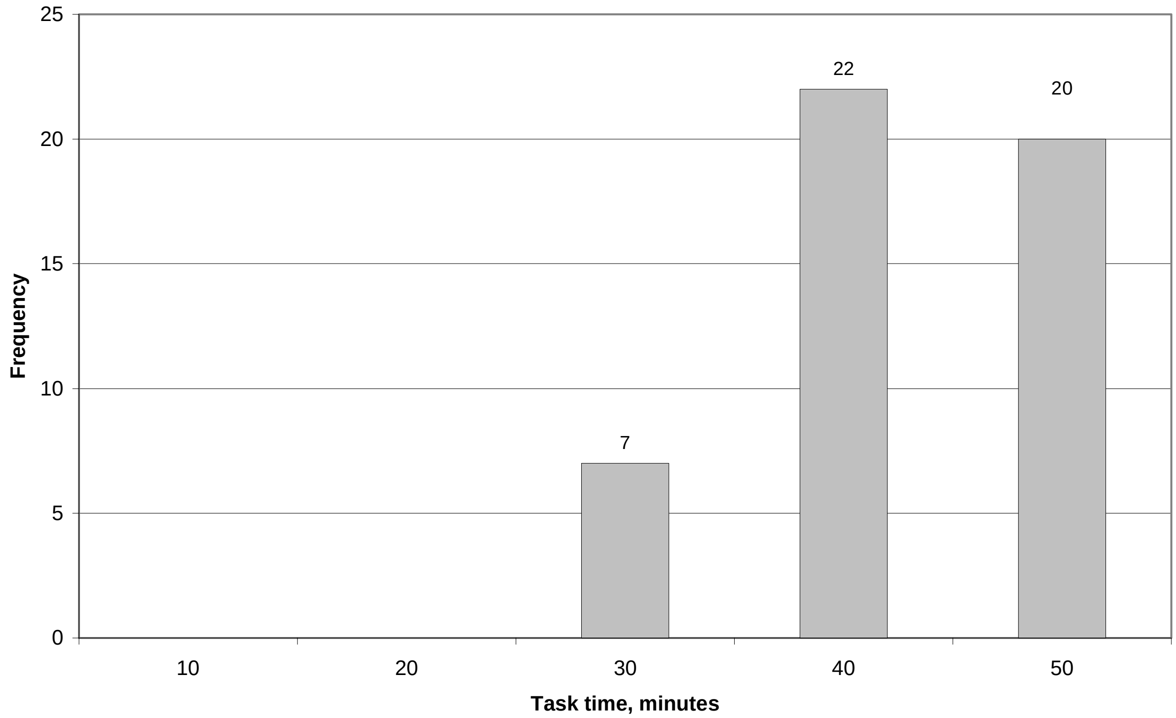


Figure 44. Task A – Actual inspection time.

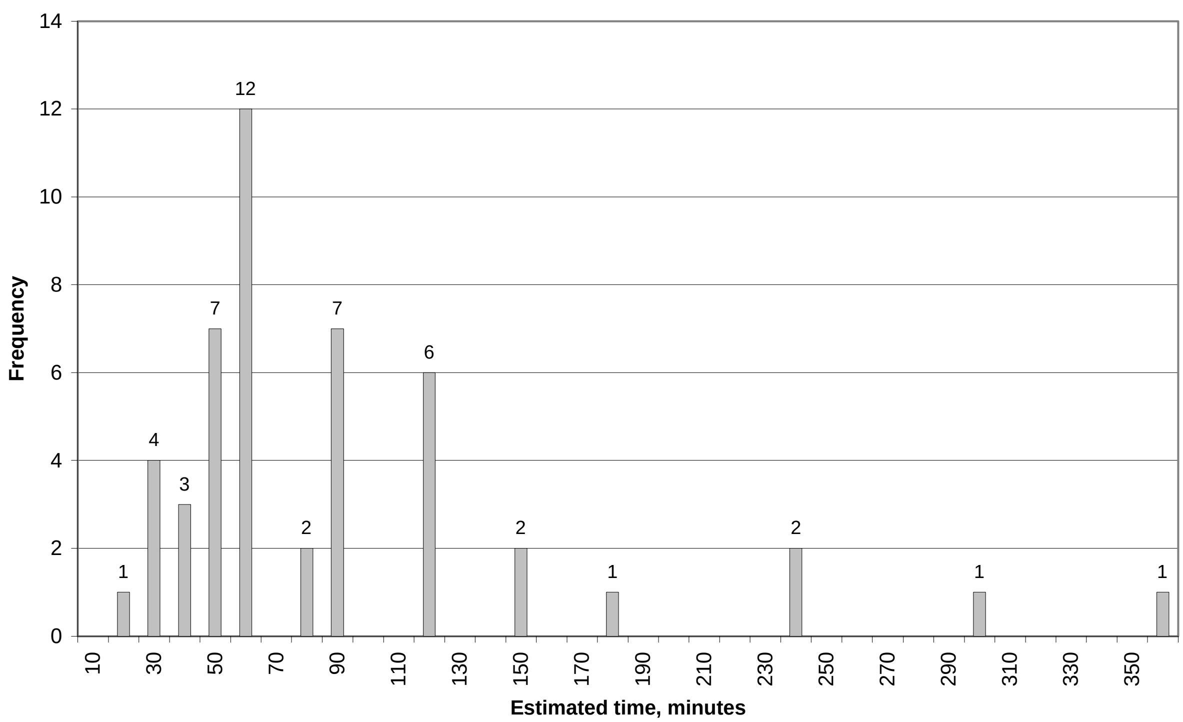


Figure 45. Task A – Predicted inspection time.

Table 21. Task A – Quantitative pre-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How long has it been since you completed an inspection of a bridge of this type (in weeks)?	N/A*	N/A	26.8	64.2	416	1
Given the available equipment and the defined tasks, how long do you think you would normally spend on this inspection (in minutes)?	N/A	N/A	90.1	70.0	360	20
How rested are you?	1 = very tired	9 = very rested	7.2	1.3	9	3

* N/A = Not applicable.

of the participating inspectors had never inspected a bridge similar to Bridge B521, and the time since a similar inspection only considers inspectors who had inspected a similar bridge. Also, the average predicted time, as shown in the table, was 125 percent more than was being allowed. Finally, table 21 shows that, overall, inspectors indicated a relatively high rested level before beginning this task. It should be pointed out that Task A was typically the first task performed in the morning or after lunch.

During Task A, inspectors were provided with two ladders (a 2.4-m stepladder and a 9.75-m extension ladder) and given full access to the superstructure from below. In order to assess what types of access equipment would normally be used for this type of an inspection, inspectors were asked to describe the type of equipment they would typically use. Table 22 summarizes their responses. Although none occurs here, the “Other” category of respondents would typically be specialized pieces of equipment that could not feasibly be grouped in another category. Note that some inspectors indicated that they would use multiple types of access equipment and therefore the sum of percentages is greater than 100 percent.

Table 22. Task A – Normal access equipment use.

Accessibility Equipment/Vehicle Type	Percentage of Respondents
Snooper	10%
Lift	24%
Ladder	51%
Scaffolding	0%
Climbing Equipment	0%
Permanent Inspection Platform	0%
Movable Platform	2%
None	20%
Other	0%

Prior to initiation of the inspection, the inspectors were asked to describe the type of construction used on the bridge. The goal of this question was to assess if inspectors recognized important aspects of the structure that could influence how it should be inspected. The results from this question are summarized in table 23. The 39 percent of the inspectors indicating an "Other" characteristic typically were providing a description of the type of bearing. Only 6 percent of the inspectors indicated that the structure was simply supported and only 4 percent noted that the bridge was skewed.

Table 23. Task A – Description of type of construction used.

Bridge Characteristic	Percentage of Respondents
Floor beams	65%
Riveted	65%
Cast-in-place concrete slab	61%
Steel through girder	59%
Plate girder	53%
Fracture-critical	45%
Simply supported	6%
Skewed	4%
Asphalt overlay	4%
Other	39%

To further assess inspector familiarity with similar inspections, inspectors were asked to identify problems that they might expect to find on a bridge of a similar type, general condition, and age. The responses are summarized in table 24. The 47 percent "Other" responses could generally be grouped into five categories: bearing problems, pack rust, joint deterioration, chloride contamination, and abnormal member distortions.

Table 24. Task A – Problems expected.

Problem Type	Percentage of Respondents
Steel corrosion or section loss	86%
Concrete deterioration	75%
Fatigue-cracking	29%
Leakage	29%
Underside deck cracking	22%
Missing rivets or rivet heads	20%
Paint deterioration	18%
Settlement cracking of abutments	16%
Cracked or loose asphalt	14%
Leaching	12%
Impact damage	10%
Inadequate concrete cover	4%
Other	47%

While the inspector was completing the inspection, the observer had three primary duties to complete. First, to monitor and record the environmental conditions. Second, to record which portions of the bridge were inspected. Finally, to note what inspection tools were used. Tables 25 through 28 summarize this information. Table 25 presents the direct environmental measurements made during the inspections, including temperature, humidity, heat index (calculated from the temperature and humidity), wind speed, and light intensity at two locations. To supplement the environmental data presented in table 25, a qualitative descriptor of the environmental conditions was also noted and is summarized in table 26.

Table 25. Task A – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (°C)	22.7	5.5	31.7	12.2
Humidity (%)	61.5	17.9	89	28
Heat Index (°C)	23	5.6	32	12
Wind Speed (km/h)	5.1	6.6	22.5	0.0
Light Intensity Under Center of Superstructure (lux)	15,290	22,290	96,190	226
Light Intensity at Deck Level (lux)	43,240	38,850	122,450	1,420

Table 26. Task A – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	29%
20 – 40% Cloudy	22%
40 – 60% Cloudy	0%
60 – 80% Cloudy	2%
80 – 100% Cloudy	12%
Hazy	6%
Fog	4%
Drizzle	18%
Steady Rain	6%
Thunderstorm	0%

In order to document an inspector's activities during the inspection, a list of some important inspection items was developed. When an inspector inspected a certain portion of the structure, regardless of how thoroughly it may have been completed, the observer noted that the item had been inspected. The data for Task A are presented in table 27. From this table, the percentage of inspectors completing each specific inspection item can be observed. It is clear from the data that the majority of the inspectors initiated most of the recorded "inspect" items. However, although all inspectors inspected both abutments, less than 70 percent were observed looking at the wingwalls and very few did any sounding of the substructure.

The observers also noted which inspection tools were used. This information is presented in table 28. Note how few inspectors used the ladder, a flashlight, or any sounding tools.

As with all tasks, the Task A post-task questions were typically related to the inspector's impression of the inspection, as well as the inspector's mental and physical condition. In all, 11 quantitative questions were asked for this task, with the results presented in table 29. The data in this table show that, in general, the inspectors felt that Task A was fairly similar to their normal inspections. Not surprisingly, they also reported that the task was fairly accurate at measuring their inspection skills. It can also be seen that, as compared to the results in table 21, the inspectors were slightly less rested at the completion of the task than at the initiation. Furthermore, inspectors felt that they understood the instructions that they were given, and most thought that, overall, the bridge was fairly accessible. Inspectors reported that being observed

Table 27. Task A – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
General	Check Overall Alignment (west side)	26%
	Check Overall Alignment (east side)	28%
Superstructure	Inspect East Girder	98%
	Inspect West Girder	100%
	Inspect North Bearings	92%
	Inspect South Bearings	96%
	Inspect Floorbeams	100%
	Inspect East Girder Above Deck Level	96%
	Inspect West Girder Above Deck Level	98%
	Inspect East Transverse Stiffeners	90%
	Inspect West Transverse Stiffeners	92%
Substructure	Inspect North Abutment	100%
	Sound North Abutment	18%
	Inspect South Abutment	100%
	Sound South Abutment	18%
	Inspect Northwest Wingwall	67%
	Sound Northwest Wingwall	2%
	Inspect Northeast Wingwall	63%
	Sound Northeast Wingwall	2%
	Inspect Southwest Wingwall	65%
	Sound Southwest Wingwall	6%
	Inspect Southeast Wingwall	60%
	Sound Southeast Wingwall	4%
Deck	Inspect East Curb	94%
	Sound East Curb	18%
	Inspect West Curb	98%
	Sound West Curb	20%
	Inspect East Curb to Web Interface	88%
	Inspect West Curb to Web Interface	86%
	Inspect North Transverse Expansion Joint	71%
	Inspect South Transverse Expansion Joint	55%
	Inspect Underside of Deck	98%

Table 28. Task A – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	24%
2.4-m Stepladder	0%
9.75-m Extension Ladder	55%
Any Flashlight	16%
Two AA-Cell Flashlight	0%
Three D-Cell Flashlight	4%
Lantern Flashlight	12%
Any Sounding Tool	45%
Masonry Hammer	45%
Chain	2%
Level as a Level	0%
Level as a Straightedge	0%
Binoculars	22%
Magnifying Glass	2%
Engineering Scale	6%
Protractor	4%
Plumb Bob	0%
String	0%
Hand Clamp	0%

had minimal influence on their performance. They reported their effort level was, on average, about the same as normal and that they were slightly less thorough than normal. In most cases, when inspectors indicated that they were less thorough than normal, this was often attributed to not having sufficient time to gain access to particular bridge components, such as every vertical stiffener in the superstructure. It should be pointed out that the average reported rushed level for Task A equaled that of Task E, both reporting average rushed levels of 3.6 — the highest encountered in this study. This indicates that inspectors may have thought that they needed additional time to complete the inspection.

5.2.2.2. TASK B

Task B is the Routine Inspection of Bridge B101A, a single-span, concrete T-beam bridge. Inspectors were given 50 min to complete the inspection, with the average inspector using 35 min (standard deviation of 11 min) and a minimum and maximum completion time of 14 min and 55 min, respectively. Figure 46 shows the distribution of inspection times.

Table 29. Task A – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How similar were these inspection tasks to the tasks performed in your normal Routine Inspections?	1 = not similar	9 = very similar	7.1	2.0	9	1
Did this task do an accurate job of measuring your inspection skills?	1 = not accurate	9 = very accurate	7.1	1.5	9	2
How rested are you?	1 = very tired	9 = very rested	7.1	1.3	9	3
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.4	0.7	9	7
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	7.7	1.1	9	6
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	5.9	1.3	8	3
How complex was this bridge?	1 = very simple	9 = very complex	4.1	1.2	6	2
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	2.7	2.0	7	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	3.6	2.6	9	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	5.0	0.6	7	3
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	4.3	1.3	6	1

Table 30 summarizes the quantitative pre-task question responses for Task B. On average, it had been about 5 months since inspectors had inspected a similar bridge. One inspector indicated that he had never inspected a bridge similar to Bridge B101A. There was significant variability in the predicted time (see figure 47) required to complete the inspection (15 min to 480

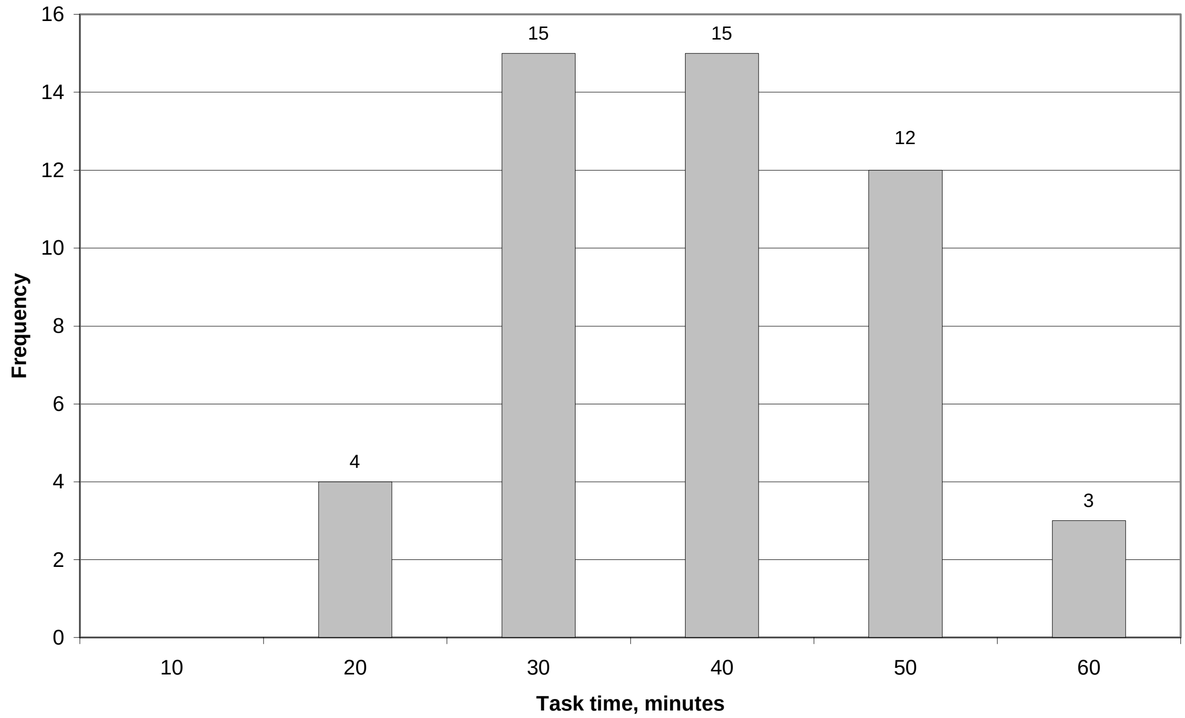


Figure 46. Task B – Actual inspection time.

min) and the average predicted time was about 70 percent more than was being allowed. At the initiation of Task B, the average inspector indicated that they were as rested as they were at the beginning of Task A (average rested level of 7.2).

As during Task A, inspectors were provided with ladders and were allowed full access to the superstructure from below. Table 31 illustrates the types of access equipment that inspectors indicated they would typically have used to complete Task B.

Although Bridge B101A is a relatively simple structure, there are some key attributes of the bridge that may influence how it should be inspected. Table 32 presents the inspector responses regarding the type of construction used on Bridge B101A. Although nearly all inspectors indicated that the bridge was constructed using concrete T-beams, only two inspectors (4 percent) indicated that the structure was simply supported. For this question, the “Other” responses were typically related to the deck/wearing surface and that there was only one span.

Table 30. Task B – Quantitative pre-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How long has it been since you completed an inspection of a bridge of this type (in weeks)?	N/A*	N/A	21.0	43.5	208	1
Given the available equipment and the defined tasks, how long do you think you would normally spend on this inspection (in minutes)?	N/A	N/A	83.8	93.4	480	15
How rested are you?	1 = very tired	9 = very rested	7.2	1.3	9	3

* N/A = Not applicable

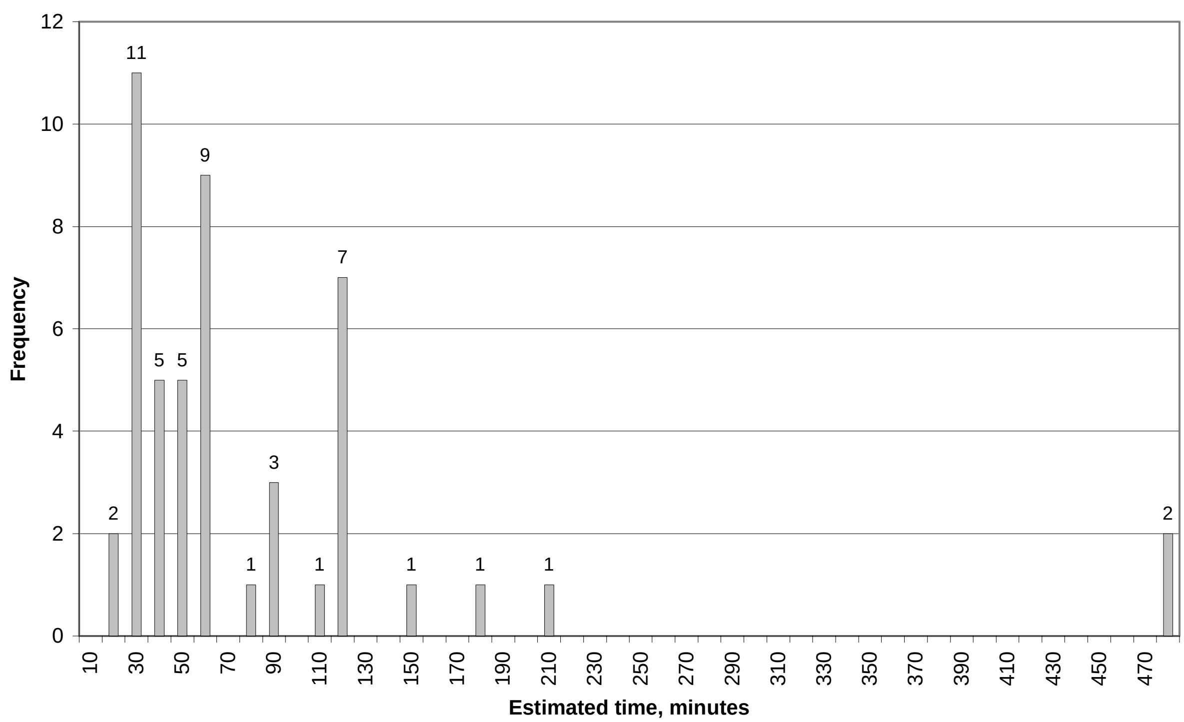


Figure 47. Task B – Predicted inspection time.

Table 31. Task B – Normal access equipment use.

Accessibility Equipment/Vehicle Type	Percentage of Respondents
Snooper	0%
Lift	14%
Ladder	57%
Scaffolding	0%
Climbing Equipment	0%
Permanent Inspection Platform	0%
Movable Platform	0%
None	20%
Other	0%

Table 32. Task B – Description of type of construction used.

Bridge Characteristic	Percentage of Respondents
Concrete T-Beam	94%
Cast-in-Place Reinforced Concrete Deck	77%
Simply Supported	4%
Other	13%

Inspector responses regarding anticipated problems are summarized in table 33. Note that 100 percent of the inspectors expected to find concrete deterioration; however, there was less consensus on how that deterioration would be manifested (concrete spalling was the most frequently cited response). For this question, two typical responses in the "Other" category were chloride contamination and general misalignment.

Table 33. Task B – Problems expected.

Problem Type	Percentage of Respondents
Concrete Deterioration	100%
Concrete Spalling	65%
Concrete Delamination	38%
Underside Cracking of Deck	38%
Leaching	33%
Leakage	27%
Settlement Cracking of Abutments	21%
Inadequate Concrete Cover	10%
Expansion Joint Deterioration	8%
Freeze/Thaw Damage	6%
Impact Damage	4%
Other	8%

As during Task A, the observer monitored the environmental conditions, what inspection items were initiated, and what tools were used. Tables 34 through 37 summarize these observations. From table 34, there generally was very little light under the superstructure and the average temperature was just slightly cooler under the bridge during Task B than during Task A. Table 35 indicates that the inspections were typically performed when the sky was fairly clear; however, 18 percent of the inspectors did complete the inspection in rain or drizzle. From table 36, it can be seen that, with the exception of inspecting the joints, there was a greater than 50 percent item initiation rate on all "inspect" items, while there was less than a 50 percent inspection item initiation rate on all "sound" items. This information, along with the data from table 37, indicates that only about half of the inspectors used the sounding equipment to assess the extent of the concrete deterioration. Even though there was minimal light below the superstructure, only 10 percent of the inspectors used a flashlight. As had been previously mentioned, Bridge B101A has a significant bow in the east abutment wall. Ten percent of the inspectors used the 610-mm level as a straightedge to estimate the amount of bowing. The one inspector (2 percent) who used the string, used it to extend the length of the plumb bob string.

Table 38 summarizes the 11 questions administered at the completion of Task B. From these data, it can be seen that, in general, the inspectors thought that Task B was similar to their normal inspections and required about the same effort level. Note that upon completion of this task, the rested level had dropped from an average of 7.2 at the beginning of the task down to an average of 7.0.

5.2.2.3. TASK C

Similar to Task B, Task C consisted of the Routine Inspection of Bridge B111A, a decommissioned, single-span, concrete T-beam bridge. Inspectors were allowed 30 min to complete the inspection, with the inspectors using an average of 24 min (standard deviation of 6 min), with a minimum and maximum completion time of 11 and 34 min, respectively. Figure 48 shows the distribution of inspection times.

Table 34. Task B – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (°C)	22.2	5.37	31.7	10.0
Humidity (%)	61.4	17.7	87	29
Heat Index (°C)	22	5.4	32	10
Wind Speed (km/h)	2.6	2.8	12.9	0.0
Light Intensity Under Center of Superstructure (lux)	73	57	228	5
Light Intensity at Deck Level (lux)	42,070	31,650	108,350	1,940

Table 35. Task B – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	47%
20 – 40% Cloudy	12%
40 – 60% Cloudy	4%
60 – 80% Cloudy	6%
80 – 100% Cloudy	12%
Hazy	0%
Fog	0%
Drizzle	12%
Steady Rain	6%
Thunderstorm	0%

Table 36. Task B – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
Superstructure	Inspect T-Beams	100%
	Sound T-Beams	24%
	Inspect Longitudinal Expansion Joint	90%
Substructure	Inspect West Abutment	100%
	Sound West Abutment	43%
	Inspect West Abutment Joint	90%
	Sound Near West Abutment Joint	33%
	Inspect East Abutment	100%
	Sound East Abutment	35%
	Inspect East Abutment Joint	88%
	Sound Near East Abutment Joint	24%
	Inspect Northeast Wingwall	59%
	Sound Northeast Wingwall	10%
	Inspect Northwest Wingwall	61%
	Sound Northwest Wingwall	16%
	Inspect Southeast Wingwall	61%
	Sound Southeast Wingwall	12%
	Inspect Southwest Wingwall	65%
	Sound Southwest Wingwall	12%
	Inspect Northeast Wingwall/Abutment Joint	86%
	Sound Northeast Wingwall/Abutment Joint	22%
	Inspect Northwest Wingwall/Abutment Joint	96%
	Sound Northwest Wingwall/Abutment Joint	31%
	Inspect Southeast Wingwall/Abutment Joint	86%
	Sound Southeast Wingwall/Abutment Joint	24%
	Inspect Southwest Wingwall/Abutment Joint	92%
	Sound Southwest Wingwall/Abutment Joint	31%
Deck	Inspect North Parapet	96%
	Sound North Parapet	19%
	Inspect South Parapet	92%
	Sound South Parapet	16%
	Inspect Underside of Deck	96%
	Sound Underside of Deck	20%
	Inspect Wearing Surface	94%
	Inspect West Transverse Expansion Joint	45%
	Inspect East Transverse Expansion Joint	39%

Table 37. Task B – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	41%
2.4-m Stepladder	0%
9.75-m Extension Ladder	24%
Any Flashlight	10%
Two AA-Cell Flashlight	0%
Three D-Cell Flashlight	8%
Lantern Flashlight	2%
Any Sounding Tool	53%
Masonry Hammer	51%
Chain	4%
Level as a Level	4%
Level as a Straightedge	10%
Binoculars	0%
Magnifying Glass	0%
Engineering Scale	2%
Protractor	0%
Plumb Bob	6%
String	2%
Hand Clamp	0%

Because of the similarity of Bridge B111A to the bridge inspected during Task B (Bridge B101A), many of the pre- and post-task questions were not repeated for Task C. The only question asked before the inspectors began Task C was related to their rested level. The inspectors reported an average rested level of 7.0 (standard deviation of 1.2), with a minimum and maximum of 3 and 9, respectively. Note that the average rested level at the completion of Task B was also 7.0 (standard deviation of 1.3).

Table 39 summarizes the measured environmental conditions and table 40 gives the qualitative weather condition during Task C. As before, the majority of the inspections were completed on mostly sunny days, with conditions similar to those recorded during Task B.

Table 38. Task B – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How similar were these inspection tasks to the tasks performed in your normal Routine Inspections?	1 = not similar	9 = very similar	7.9	1.2	9	5
Did this task do an accurate job of measuring your inspection skills?	1 = not accurate	9 = very accurate	7.6	1.0	9	5
How rested are you?	1 = very tired	9 = very rested	7.0	1.3	9	3
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.5	0.7	9	6
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	7.9	1.2	9	3
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	2.7	1.7	7	1
How complex was this bridge?	1 = very simple	9 = very complex	3.0	1.5	7	1
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	1.8	1.2	5	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	2.2	1.8	7	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	5.2	1.1	9	3
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	4.9	1.2	7	2

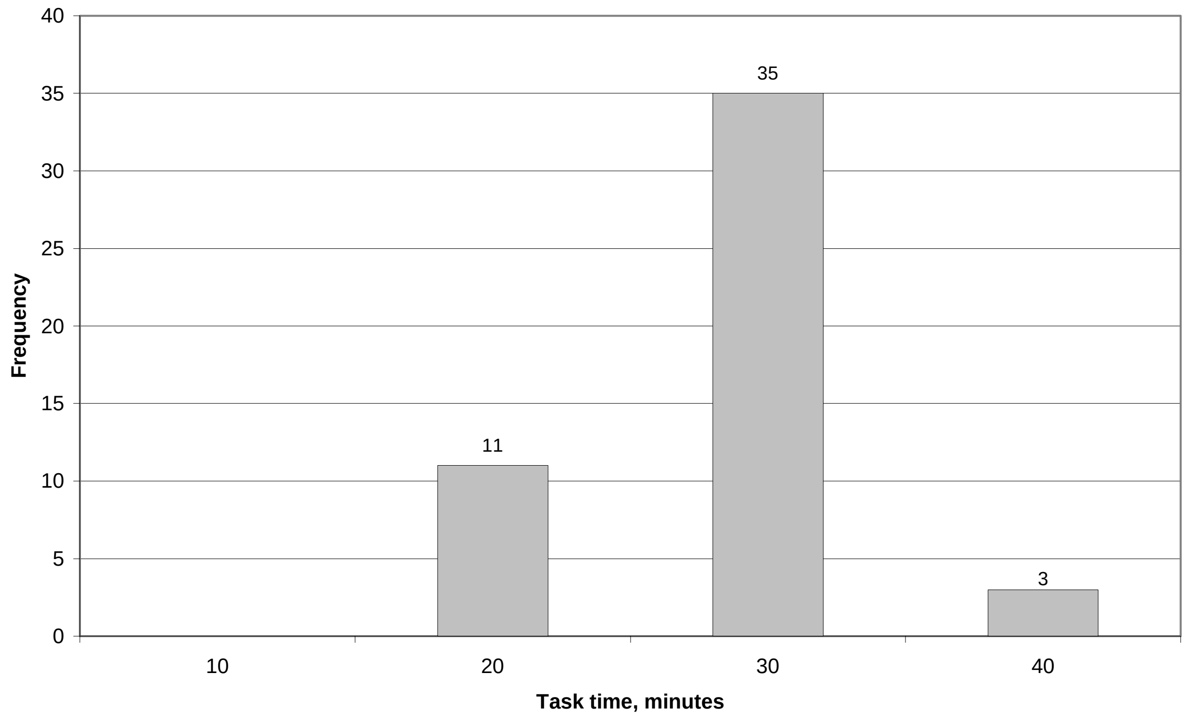


Figure 48. Task C – Actual inspection time.

Table 39. Task C – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (°C)	23.4	5.4	32.2	11.7
Humidity (%)	55.5	17.7	88	22
Heat Index (°C)	23	5.3	32	12
Wind Speed (km/h)	3.4	3.4	11.3	0.0
Light Intensity Under Center of Superstructure (lux)	226	108	549	28
Light Intensity at Deck Level (lux)	49,180	35,870	115,890	4,090

Table 40. Task C – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	45%
20 – 40% Cloudy	14%
40 – 60% Cloudy	4%
60 – 80% Cloudy	0%
80 – 100% Cloudy	18%
Hazy	4%
Fog	0%
Drizzle	10%
Steady Rain	4%
Thunderstorm	0%

Table 41 summarizes the inspection item data for Task C. It should be reiterated that inspectors were not allowed to use a ladder to access the superstructure due to the traffic volume, speeds, and sight distances near the bridge. As with previous tasks, the majority of the inspectors completed most of the “inspect” items, while few completed the “sounding” items. Furthermore, inspectors generally completed fewer “sounding” inspection items during Task C than they did during Task B. This can probably be attributed to two factors. First, the overall condition of the Task B bridge is generally worse than that of the Task C bridge. Second, familiarity with the Task B bridge probably led to a greater confidence in their ability to visually determine the condition of the Task C bridge, thereby requiring less sounding. Overall, the use of the inspection tools was very limited during Task C, as summarized in table 42. It can also be seen that 31 percent of the inspectors used the masonry hammer and that no other tool was used by more than 10 percent of the inspectors.

Upon completion of Task C, inspectors were again asked a series of questions. Certain questions asked following Task B were omitted from the Task C series of questions. Table 43 summarizes the responses. Similar to previous tasks, the completion of the task resulted in the average inspector “Rested Level After Task” dropping from 7.0 to 6.9. As one would expect, inspectors generally indicated that the Task C bridge had been maintained better than the Task B bridge (4.1 versus 2.7).

Table 41. Task C – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
Superstructure	Inspect T-Beams	100%
	Sound T-Beams	0%
	Inspect Longitudinal Expansion Joint	90%
Substructure	Inspect West Abutment	100%
	Sound West Abutment	20%
	Inspect West Abutment Joint	94%
	Sound Near West Abutment Joint	20%
	Inspect East Abutment	100%
	Sound East Abutment	39%
	Inspect East Abutment Joint	86%
	Sound Near East Abutment Joint	39%
	Inspect Northeast Wingwall	49%
	Sound Northeast Wingwall	10%
	Inspect Northwest Wingwall	53%
	Sound Northwest Wingwall	8%
	Inspect Southeast Wingwall	47%
	Sound Southeast Wingwall	8%
	Inspect Southwest Wingwall	49%
	Sound Southwest Wingwall	6%
	Inspect Northeast Wingwall to Abutment Joint	82%
	Sound Northeast Wingwall to Abutment Joint	14%
	Inspect Northwest Wingwall to Abutment Joint	78%
	Sound Northwest Wingwall to Abutment Joint	16%
	Inspect Southeast Wingwall to Abutment Joint	80%
	Sound Southeast Wingwall to Abutment Joint	18%
	Inspect Southwest Wingwall to Abutment Joint	78%
	Sound Southwest Wingwall to Abutment Joint	12%
Deck	Inspect North Parapet	90%
	Sound North Parapet	13%
	Inspect South Parapet	94%
	Sound South Parapet	12%
	Inspect Underside of Deck	100%
	Sound Underside of Deck	0%
	Inspect Wearing Surface	98%
	Inspect West Transverse Expansion Joint	27%
	Inspect East Transverse Expansion Joint	35%

Table 42. Task C – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	8%
2.4-m Stepladder	0%
9.75-m Extension Ladder	0%
Any Flashlight	8%
Two AA-Cell Flashlight	0%
Three D-Cell Flashlight	6%
Lantern Flashlight	2%
Any Sounding Tool	33%
Masonry Hammer	31%
Chain	4%
Level as a Level	0%
Level as a Straightedge	0%
Binoculars	0%
Magnifying Glass	0%
Engineering Scale	0%
Protractor	0%
Plumb Bob	0%
String	0%
Hand Clamp	0%

5.2.2.4. TASK D

In this task, inspectors were asked to complete a Routine Inspection of Bridge B543. In addition to providing the standard Condition Ratings and field notes, inspectors were asked to use a digital camera to provide visual documentation of their findings. Results related to these photographs will be discussed in a subsequent section. Inspectors were allotted 40 min to complete Task D, with an average time used of 30 min (standard deviation of 7 min). The minimum and maximum completion times were 18 and 43 min, respectively. The distribution of inspection times is shown in figure 49.

As has been described previously, table 44 summarizes the quantitative pre-task questions for Task D. On average, it had been more than 6 months since the inspectors had last inspected a similar bridge. The average estimated inspection time was 68 min (70 percent more time than allotted). One inspector indicated that the inspection would only require 12 min to complete, while another inspector anticipated needing 5 h. The distribution of predicted inspection times is shown in figure 50.

Table 43. Task C – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How rested are you?	1 = very tired	9 = very rested	6.9	1.3	9	3
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.5	0.6	9	6
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	7.4	1.4	9	1
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	4.1	1.8	8	1
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	1.7	1.1	6	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	2.6	2.3	9	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	4.9	1.1	8	1
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	4.9	1.3	8	1

Although inspectors were provided with the two ladders described previously, the geometry of Bridge B543 is such that they could not safely be used to access the underside of the superstructure. Table 45 summarizes the types of access equipment that inspectors indicated they would typically use on an inspection similar to Task D. Note that the most common response was that no access equipment would normally be used.

As before, inspectors were asked to describe the type of construction used on the bridge. Table 46 summarizes the responses. One important result from this table is that none of the inspectors noted that the bridge was skewed, despite the fact that skew on this type of bridge has implications on the overall structural behavior. It should also be noted that most of the “Other”

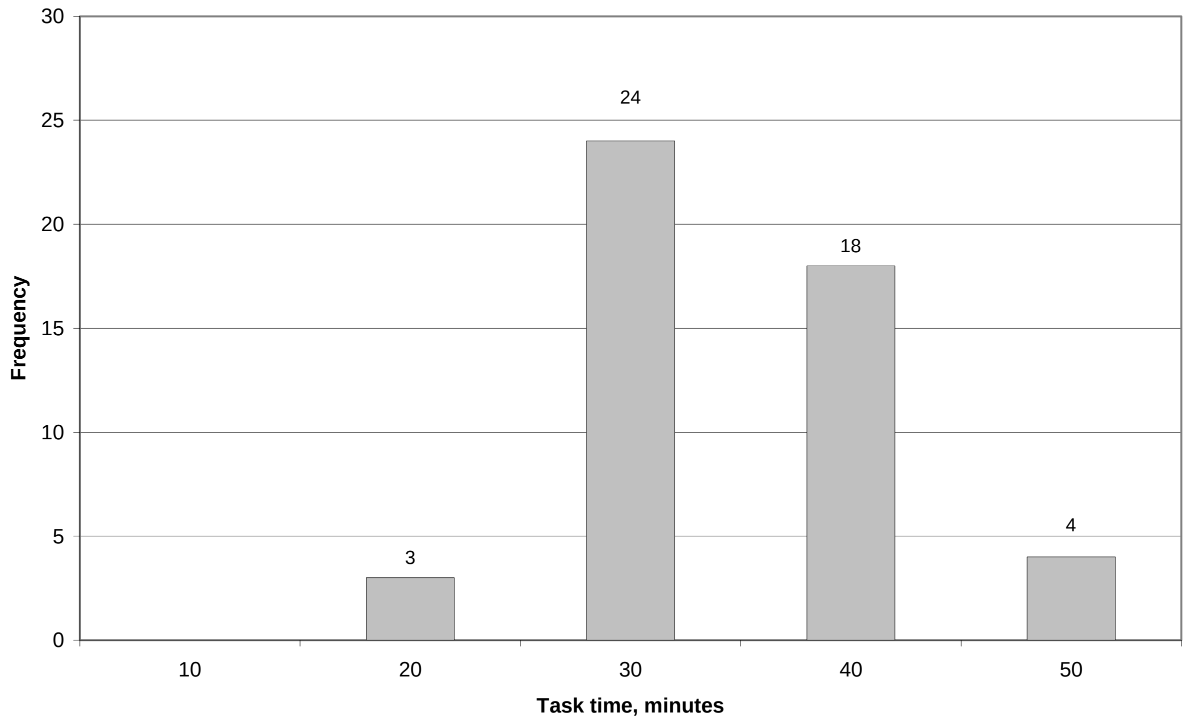


Figure 49. Task D – Actual inspection time.

responses were responses related to the general structure type, such as arch, concrete arch, arch slab, slab bridge, concrete box, etc., that did not precisely fit with the "concrete rigid frame" description. Other responses in this category described the substructure or the asphalt overlay.

As shown in table 47, when the inspectors were asked what types of deterioration they might expect to find on Bridge B543, only 8 percent indicated that they expected to find freeze/thaw damage. Note that the physical conditions at the bridge included concrete parapets that are severely deteriorated and this deterioration is very obvious as one approaches the bridge. As shown in table 47, the specific types of deterioration that they were expecting to find were quite varied, with "concrete spalling" being the most commonly cited. The two "Other" responses were related to the bridge joints and initial construction defects.

Table 44. Task D – Quantitative pre-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How long has it been since you completed an inspection of a bridge of this type (in weeks)?	N/A*	N/A	28.8	39.7	225	1
Given the available equipment and the defined tasks, how long do you think you would normally spend on this inspection (in minutes)?	N/A	N/A	67.5	43.3	300	12
How rested are you?	1 = very tired	9 = very rested	7.0	1.2	9	4

* N/A = Not applicable.

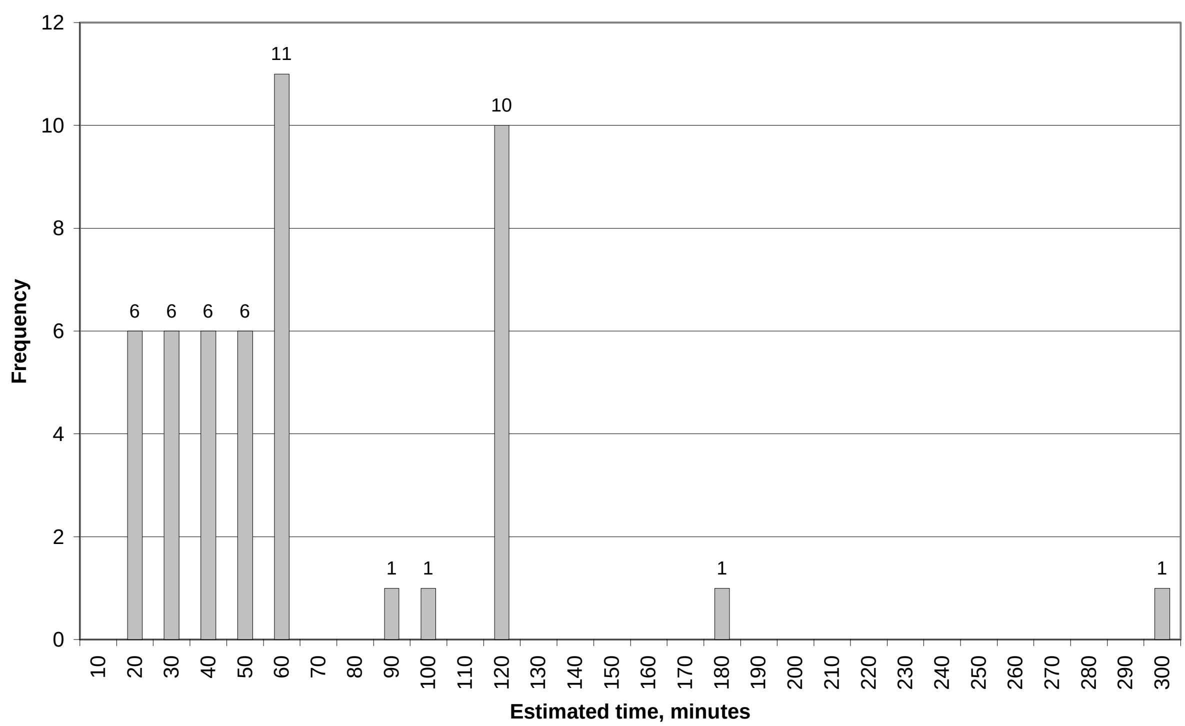


Figure 50. Task D – Predicted inspection time.

Table 45. Task D – Normal access equipment use.

Accessibility equipment/vehicle type	Percentage of Respondents
Snooper	0%
Lift	20%
Ladder	35%
Scaffolding	0%
Climbing Equipment	0%
Permanent Inspection Platform	0%
Movable Platform	2%
None	41%
Other	0%

Table 46. Task D – Description of type of construction used.

Bridge Characteristic	Percentage of Respondents
Concrete rigid frame	63%
Skewed	0%
Other	39%

Table 47. Task D – Problems expected.

Problem Type	Percentage of Respondents
Concrete Deterioration	96%
Concrete Spalling	45%
Underside Cracking of Deck	39%
Settlement Cracking of Abutments	33%
Concrete Delamination	29%
Leaching	24%
Leakage	20%
Expansion Joint Deterioration	14%
Inadequate Concrete Cover	10%
Freeze/Thaw Damage	8%
Impact Damage	6%
Other	4%

Data collected by the observers during this task are presented in tables 48 through 51. From the data on the weather conditions (tables 48 and 49), it can be seen that Task D was completed under various conditions. Bridge B543 is located in a fairly unique location. The top of the deck is very exposed and the landscape offers little protection from sun, wind, or rain. However, the area under the bridge is very well protected and offers inspectors shelter from the weather, while at the same time lowering the light intensity. Table 50 summarizes the inspection item data. Interestingly, 88 percent of the inspectors inspected the south elevation, but only 67 percent inspected the north elevation. This is possibly attributable to the relatively steep terrain on the north side. This fact indicates that structure accessibility can have an influence on how an inspection is completed. Almost no sounding was performed on this bridge. From table 51, it can be seen that 4 percent of the inspectors used a ladder during the inspection. These inspectors used the ladder to inspect and/or sound the abutment wall and the abutment-to-deck interface. In addition, note that only 18 percent of the inspectors used a flashlight even though the embankment on the north end limited the light intensity under the bridge.

Table 48. Task D – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (°C)	23.9	4.8	31.1	13.3
Humidity (%)	55.5	15.4	81	27
Heat Index (°C)	24	5.0	38	13
Wind Speed (km/h)	1.3	2.1	8.0	0.0
Light Intensity Under Center of Superstructure (lux)	415	1,702	12,020	9
Light Intensity at Deck Level (lux)	53,350	32,130	99,420	1,510

Table 49. Task D – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	41%
20 – 40% Cloudy	12%
40 – 60% Cloudy	4%
60 – 80% Cloudy	6%
80 – 100% Cloudy	18%
Hazy	0%
Fog	0%
Drizzle	8%
Steady Rain	10%
Thunderstorm	0%

Table 50. Task D – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
Superstructure	Inspect Arch for Cracking	96%
	Inspect Longitudinal Expansion Joint	96%
	Inspect North Elevation	67%
	Inspect South Elevation	88%
Substructure	Inspect West Abutment	100%
	Sound West Abutment	20%
	Inspect East Abutment	100%
	Sound East Abutment	20%
	Inspect Northeast Wingwall	16%
	Sound Northeast Wingwall	4%
	Inspect Northwest Wingwall	39%
	Sound Northwest Wingwall	4%
	Inspect Southeast Wingwall	59%
	Sound Southeast Wingwall	6%
	Inspect Southwest Wingwall	63%
	Sound Southwest Wingwall	6%
Deck	Inspect North Parapet	100%
	Sound North Parapet	10%
	Inspect South Parapet	100%
	Sound South Parapet	12%
	Inspect Wearing Surface	96%
	Inspect West Transverse Expansion Joint	33%
	Inspect East Transverse Expansion Joint	33%

A series of post-task questions were asked of inspectors after completing Task D. The response data are given in table 52. The majority of these data are similar to that provided for other tasks and similar conclusions can be drawn. However, when asked about bridge accessibility, the average response was more than 7 on a scale of 1 to 9. This indicates that the inspectors felt that the bridge was fairly accessible. This is despite the fact that effectively and safely using a ladder was very difficult and the northern embankment obviously influenced accessibility.

Table 51. Task D – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	22%
2.4-m Stepladder	0%
9.75-m Extension Ladder	4%
Any Flashlight	18%
Two AA-Cell Flashlight	2%
Three D-Cell Flashlight	12%
Lantern Flashlight	4%
Any Sounding Tool	35%
Chain	4%
Masonry Hammer	33%
Level as a Level	0%
Level as a Straightedge	4%
Binoculars	0%
Magnifying Glass	0%
Engineering Scale	2%
Protractor	0%
Plumb Bob	0%
String	0%
Hand Clamp	0%

5.2.2.5. TASK E

Task E is the Routine Inspection of Bridge B544, which is a decommissioned, single-span, riveted steel bridge. Inspectors were allotted 60 min to complete the inspection, with the inspectors using an average of 52 min (standard deviation of 9 min). The quickest inspector completed the inspection in 31 min, while others used the full 60 min. The distribution of actual inspection times is shown in figure 51.

Table 53 summarizes three questions asked during the pre-task evaluation. The data show that, in general, inspectors had fairly recently inspected a similar bridge. The average predicted time to complete the task was 104 min. This average estimated time is nearly twice that being allotted and, as before, there was significant dispersion in the estimates. In fact, the longest estimated time was 21 times longer than the shortest estimate. The distribution of predicted inspection times is shown in figure 52.

Table 52. Task D – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How similar were these inspection tasks to the tasks performed in your normal Routine Inspections?	1 = not similar	9 = very similar	7.7	1.5	9	2
Did this task do an accurate job of measuring your inspection skills?	1 = not accurate	9 = very accurate	7.4	1.3	9	5
How rested are you?	1 = very tired	9 = very rested	6.8	1.4	9	2
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.4	0.6	9	7
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	7.4	1.8	9	1
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	3.6	1.8	8	1
How complex was this bridge?	1 = very simple	9 = very complex	2.8	1.6	7	1
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	1.9	1.2	6	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	2.9	2.3	7	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	5.1	0.7	7	4
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	5.0	0.8	7	3

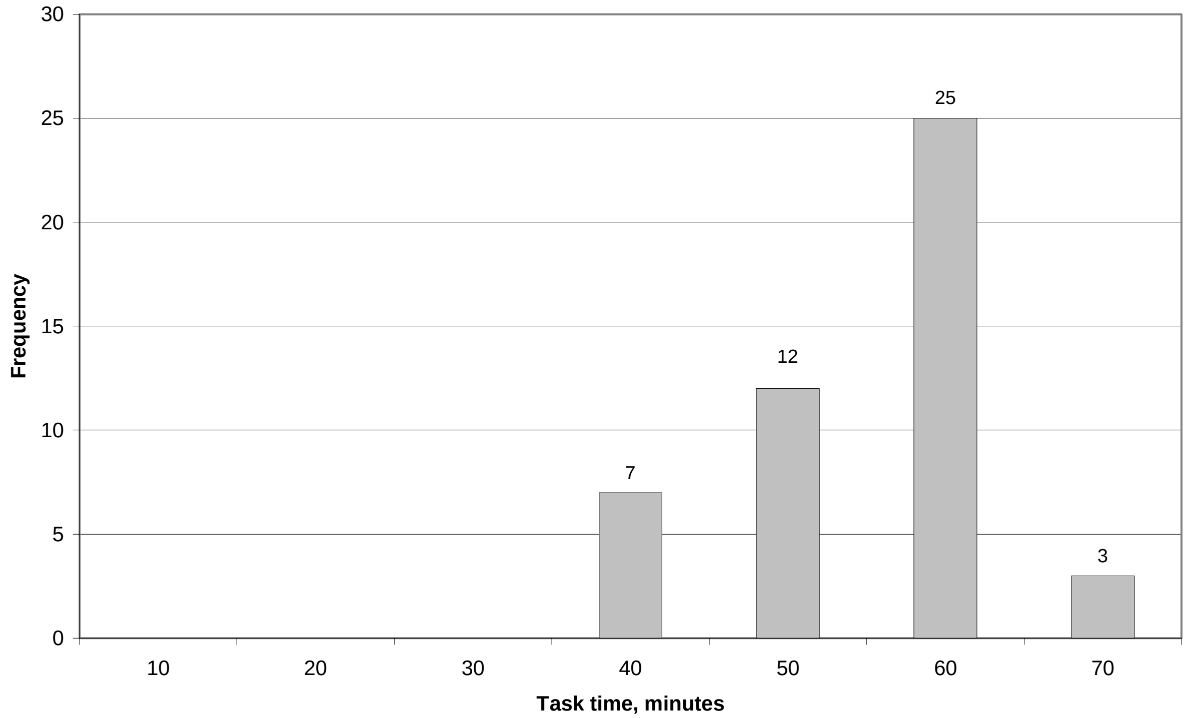


Figure 51. Task E – Actual inspection time.

Table 53. Task E – Quantitative pre-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How long has it been since you completed an inspection of a bridge of this type (in weeks)?	N/A*	N/A	16.5	20.5	104	0.5
Given the available equipment and the defined tasks, how long do you think you would normally spend on this inspection (in minutes)?	N/A	N/A	103.6	77.2	360	17
How rested are you?	1 = very tired	9 = very rested	7.1	1.1	9	5

* N/A = Not applicable.

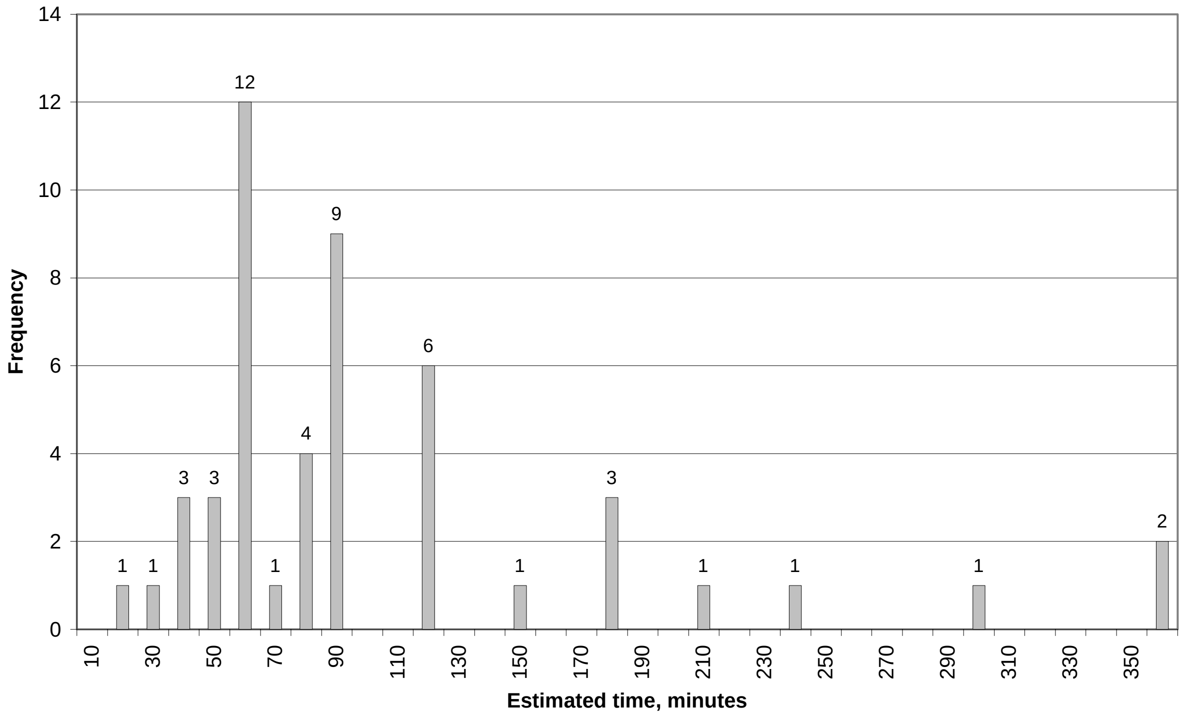


Figure 52. Task E – Predicted inspection time.

Although inspectors were provided with ladders, their use was restricted to areas that would not interfere with U.S. Route 30. Therefore, access to the superstructure was limited to areas near the bearings. Table 54 summarizes the types of access equipment that the inspectors indicated that they would typically have used. The most common responses included the use of a ladder and the use of no special access equipment. The inspectors generally indicated that because of the heavy traffic and the limited site distances due to the roadway alignment, they would only use special access equipment on this bridge to perform an In-Depth Inspection.

When the inspectors were asked to describe the type of construction used on Bridge B543, nearly all inspectors indicated that it was a riveted, steel plate girder bridge, as shown by table 55. However, only 8 percent of the inspectors noted that the bridge was skewed. The relatively large skew on this bridge influences the behavior of the bridge and could have implications on how it should be inspected. In addition, only 31 percent of the inspectors noted the unusual configuration of floor beams and sway frames. This important feature of Bridge B544 is indicative of the unusual behavior of the concrete deck (e.g., two-way slab vs. one-way slab).

Table 54. Task E – Normal access equipment use.

Accessibility Equipment/Vehicle Type	Percentage of Respondents
Snooper	10%
Lift	22%
Ladder	55%
Scaffolding	0%
Climbing Equipment	0%
Permanent Inspection Platform	0%
Movable Platform	2%
None	29%
Other	0%

Table 55. Task E – Description of type of construction used.

Bridge Characteristic	Percentage of Respondents
Steel Plate Girder	86%
Riveted	78%
CIP Concrete Slab	65%
Floor beams/Sway Frames	31%
Simply Supported	31%
Skewed	8%
Asphalt Overlay	6%
Other	20%

The most common "Other" response was related to the type of substructure. Also, one inspector indicated that the bridge did not have any welds when, in fact, there were a few welds. Finally, one inspector indicated that the superstructure was welded and another referred to the superstructure as a through-girder.

As can be seen in table 56, the most common problems that inspectors expected to find were corrosion of the steel and general concrete deterioration. "Other" types of identified deterioration included deterioration of the deck, joints, and bearings.

Tables 57 through 60 summarize the data collected by the observer during the inspection task. As can be seen from these tables, the average temperature at this bridge was slightly lower than at the other STAR bridges. This is probably due to the bridge being located in a slight depression and in a shaded area. In addition, note that a greater percentage of inspectors used the

Table 56. Task E – Problems expected.

Problem Type	Percentage of Respondents
Steel Corrosion	80%
Concrete Deterioration	76%
Cracked Asphalt	37%
Paint Deterioration	29%
Leakage	27%
Leaching	22%
Fatigue Cracks in Tack Welds	22%
Underside Deck Cracking	18%
Inadequate Concrete Cover	16%
Missing Rivets	16%
Settlement Cracking in Abutment	8%
Impact Damage	4%
Other	16%

sounding tools during this task than at the other STAR bridges. However, the use was intermittent, as evidenced by the relatively low completion rate on individual sounding items.

Table 57. Task E – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (ºC)	26.7	5.4	29.4	8.3
Humidity (%)	70.0	16.7	96	33
Heat Index (ºC)	22	5.6	30	8
Wind Speed (km/h)	2.6	4.2	16.1	0.0
Light Intensity Below Superstructure (lux)	1,290	2,160	14,030	2
Light Intensity at Deck Level (lux)	29,800	35,440	107,710	178

Table 61 presents the quantitative post-task question responses. As shown in this table, even though the inspectors had previously indicated that they would need more time than allotted, when asked if they felt rushed, the average response was a 3.6 on a scale of 1 to 9. In addition, note that, on average, the inspectors indicated that their effort level was slightly higher than normal on this task.

Table 58. Task E – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	37%
20 – 40% Cloudy	4%
40 – 60% Cloudy	6%
60 – 80% Cloudy	2%
80 – 100% Cloudy	27%
Hazy	2%
Fog	0%
Drizzle	10%
Steady Rain	12%
Thunderstorm	0%

Table 59. Task E – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
General	Check Overall Alignment (West Side)	47%
	Check Overall Alignment (East Side)	45%
Superstructure	Inspect With Binoculars	18%
	Inspect Bearings While Elevated	63%
	Measure Bearing Rotation	47%
Substructure	Inspect West Abutment	98%
	Sound West Abutment	28%
	Inspect East Abutment	98%
	Sound East Abutment	34%
	Inspect Northwest Wingwall	84%
	Sound Northwest Wingwall	12%
	Inspect Northeast Wingwall	80%
	Sound Northeast Wingwall	12%
	Inspect Southwest Wingwall	86%
	Sound Southwest Wingwall	16%
	Inspect Southeast Wingwall	86%
	Sound Southeast Wingwall	14%
Deck	Inspect Deck Surface	92%
	Inspect West Transverse Expansion Joint	82%
	Inspect East Transverse Expansion Joint	82%
	Inspect Longitudinal Joint	29%
	Inspect North Parapet	94%
	Sound North Parapet	16%
	Inspect South Parapet	92%
	Sound South Parapet	20%

Table 60. Task E – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	29%
2.4-m Stepladder	0%
9.75-m Extension Ladder	49%
Any Flashlight	24%
Two AA-Cell Flashlight	2%
Three D-Cell Flashlight	10%
Lantern Flashlight	12%
Any Sounding Tool	61%
Masonry Hammer	59%
Chain	2%
Level as a Level	0%
Level as a Straightedge	0%
Binoculars	16%
Magnifying Glass	2%
Engineering Scale	6%
Protractor	4%
Plumb Bob	0%
String	0%
Hand Clamp	0%

5.2.2.6. TASK G

As described previously, Task G is the Routine Inspection of the southern half of the U.S. Route 1 Bridge over the Occoquan River. Inspectors were given 2 h to complete the inspection. The task was completed in an average of 62 min (standard deviation of 20 min), with a minimum and maximum completion time of 14 min and 108 min, respectively. The distribution of inspection times is shown in figure 53.

Table 62 summarizes the quantitative questions from the pre-task questionnaire. Most notable from this table is the fact that, in general, the inspectors had fairly recently completed an inspection of a similar bridge. In addition, unlike the other Routine Inspection tasks, the average estimated inspection time was less than what was being allotted. A distribution of the estimated inspection times is shown in figure 54.

Table 61. Task E – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How similar were these inspection tasks to the tasks performed in your normal Routine Inspections?	1 = not similar	9 = very similar	7.7	1.3	9	3
Did this task do an accurate job of measuring your inspection skills?	1 = not accurate	9 = very accurate	7.2	1.7	9	1
How rested are you?	1 = very tired	9 = very rested	7.1	1.1	9	5
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.4	0.8	9	6
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	6.4	1.9	9	1
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	3.7	1.8	7	1
How complex was this bridge?	1 = very simple	9 = very complex	4.9	1.8	8	1
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	2.3	1.6	6	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	3.6	2.6	9	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	5.3	1.2	9	3
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	4.8	1.0	7	1

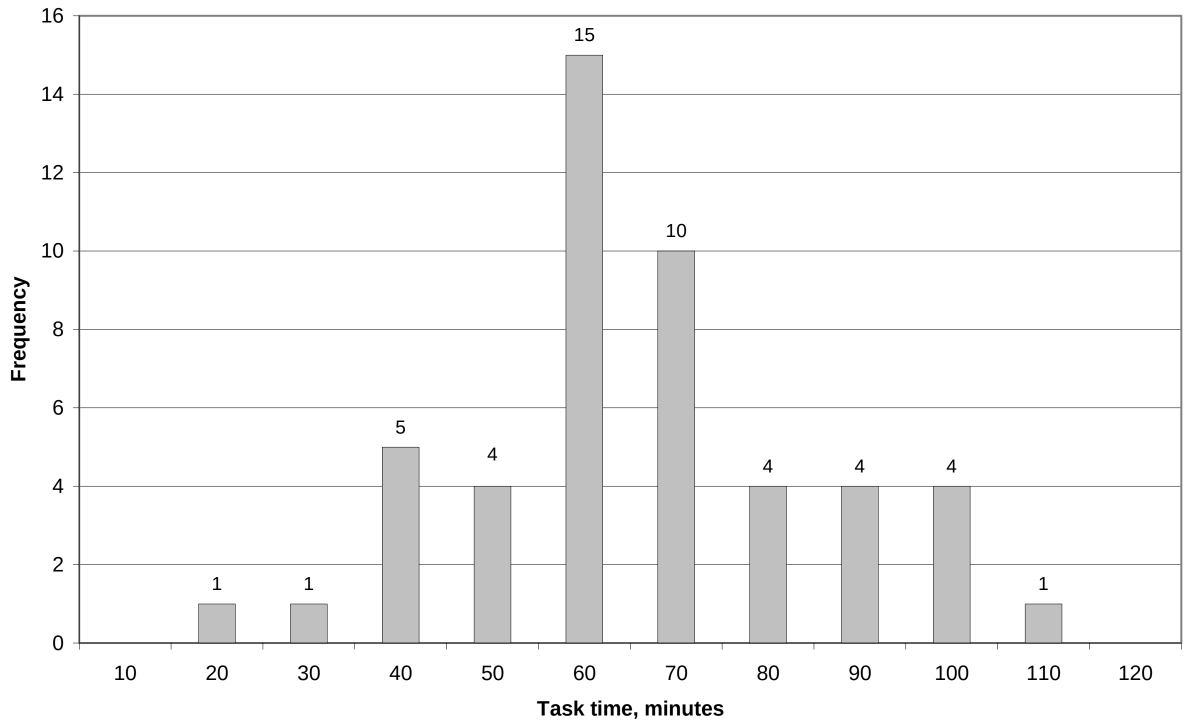


Figure 53. Task G – Actual inspection time.

Table 62. Task G – Quantitative pre-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How long has it been since you completed an inspection of a bridge of this type (in weeks)?	N/A*	N/A	14.5	21.3	104	1
Given the available equipment and the defined tasks, how long do you think you would normally spend on this inspection (in minutes)?	N/A	N/A	110.0	101.3	480	25
How rested are you?	1 = very tired	9 = very rested	7.3	1.5	9	3

* N/A = Not applicable.

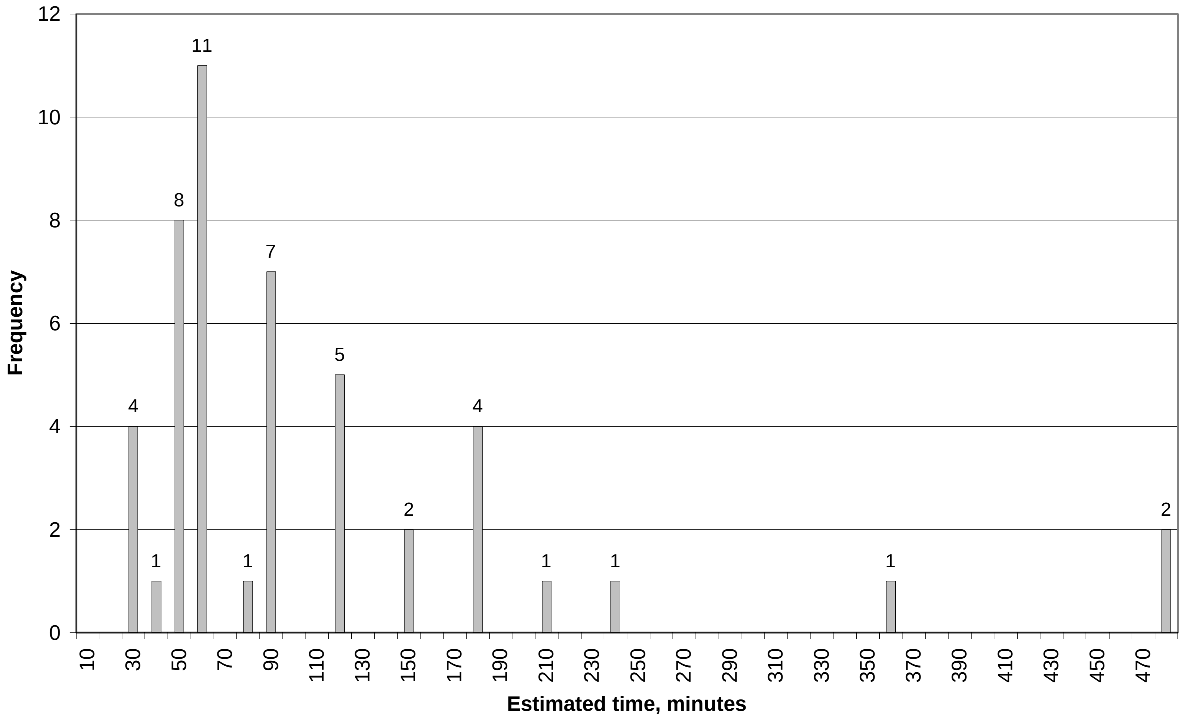


Figure 54. Task G – Predicted inspection time.

In order to assess what types of equipment the inspectors would have normally used, they were asked to describe the equipment they typically would have used. Table 63 summarizes the responses.

Table 63. Task G – Normal access equipment use.

Accessibility Equipment/Vehicle Type	Percentage of Respondents
Snooper	53%
Lift	4%
Ladder	10%
Scaffolding	0%
Climbing Equipment	0%
Permanent Inspection Platform	4%
Movable Platform	2%
None	27%
Other	0%

Within the pre-task questionnaire, the inspectors were asked to describe the type of construction used on this bridge. The results from this question are presented in table 64. These results are the same as will be presented for this question within Task H, as this question was asked only at the start of whichever of Tasks G and H was performed first. Only 51 percent of the inspectors indicated that the bridge is continuous. This can have an impact on the inspection and could lead to less accurate inspection results as a result of not identifying the critical inspection areas. The "Other" category typically contains references to the substructure and splice plates. One inspector indicated that the bridge was simply supported.

Table 64. Task G – Description of type of construction used.

Bridge Characteristic	Percentage of Respondents
Steel Girder	80%
Reinforced Concrete Deck	71%
Concrete Piers	55%
Continuous	51%
Welded Plate Girder	51%
Multi-Girder	41%
Single-Angle Cross-Bracing	12%
Rocker Bearing	6%
Composite Construction	4%
Other	18%

To further assess how they were formulating their approach to the inspection, inspectors were asked to identify problems that they might expect to find on a bridge of a similar type, condition, and age. These responses are summarized in table 65. These results show that inspectors expect relatively few types of problems to exist. Of this list of possible defects, only steel corrosion and fatigue cracks were mentioned by more than half of the inspectors and no defects were mentioned by more that 60 percent of the inspectors.

As before, tables 66 through 69 summarize data collected by the observer as the inspectors completed Task G. Temperature conditions were generally warmer than during the other Routine Inspection tasks, and due to the proximity to a major metropolitan area, there was a greater percentage of "hazy" days. Also note that approximately 80 percent of the inspectors used binoculars to inspect the superstructure, but less than 25 percent did any sounding of the substructure.

Table 65. Task G – Problems expected.

Problem Type	Percentage of Respondents
Fatigue Cracks	59%
Steel Corrosion	53%
Concrete Deterioration	49%
Underside Deck Cracking	29%
Deck Delaminations	27%
Locked Bearings	22%
Missing or Loose Bolts	20%
Expansion-Joint Deterioration	18%
Leakage	16%
Paint Deterioration	14%
Impact Damage	6%
Leaching	6%
Other	20%

Table 66. Task G – Direct environmental measurements.

Environmental Measurement	Average	Standard Deviation	Maximum	Minimum
Temperature (°C)	23.0	4.3	31.1	11.1
Humidity (%)	70.0	11.5	91	46
Heat Index (°C)	28	5.4	38	11
Wind Speed (km/h)	3.8	4.8	19.3	0.0
Light Intensity Under Center of Superstructure (lux)	13,090	15,270	65,430	441
Light Intensity on Top of South Abutment (lux)	29	30	183	1

Table 67. Task G – Qualitative weather conditions.

Weather Condition	Percentage of Inspections
0 – 20% Cloudy	43%
20 – 40% Cloudy	8%
40 – 60% Cloudy	0%
60 – 80% Cloudy	0%
80 – 100% Cloudy	29%
Hazy	10%
Fog	2%
Drizzle	4%
Steady Rain	2%
Thunderstorm	0%

Table 68. Task G – Bridge component inspection results.

	Inspection Item	Percentage of Inspectors
Superstructure	Inspect Span 5 With Binoculars	78%
	Inspect Span 6 With Binoculars	78%
	Inspect Span 7 With Binoculars	78%
	Inspect Span 8 With Binoculars	76%
	Inspect Pier 4 Bearing	76%
	Inspect Pier 5 Bearing	78%
	Inspect Pier 6 Bearing	76%
	Inspect Pier 7 Bearing	71%
Substructure	Inspect Pier 4	88%
	Sound Pier 4	4%
	Inspect Pier 5	94%
	Sound Pier 5	10%
	Inspect Pier 6	96%
	Sound Pier 6	16%
	Inspect Pier 7	100%
	Sound Pier 7	10%
	Sound Abutment Seat	24%
	Sound Abutment Backwall	22%
Deck	Inspect South Expansion Joint From Above	88%
	Inspect South Expansion Joint From Below	71%
	Check West Alignment	55%

As done after all other inspection tasks, inspectors were asked a series of questions upon completing Task G. Inspector responses are summarized in table 70. Although most inspectors initially indicated that they would have used more access equipment than was provided, upon completion of the task, most indicated that the task was quite similar to what they would normally do. However, on average, inspectors indicated that Task G was the least accurate of all the tasks at measuring their inspection skills. In addition, note that the inspectors indicated that they gave more effort than normal. This is probably attributable to the lack of special access equipment.

5.2.3. Statistical Analysis of Primary Bridge Elements

In the following sections, the statistical analyses performed on the Routine Inspection primary element Condition Ratings will be presented. The discussion has two primary sections. First,

Table 69. Task G – Use of inspection tools.

Tool	Percentage of Inspectors
Tape Measure	22%
Engineering Scale	0%
2.4-m Stepladder	0%
9.75-m Extension Ladder	0%
Any Flashlight	41%
Two AA-Cell Flashlight	16%
Three D-Cell Flashlight	10%
Lantern Flashlight	14%
Any Sounding Tool	41%
Masonry Hammer	41%
Chain	0%
Level as a Level	0%
Level as a Straightedge	0%
Binoculars	80%
Magnifying Glass	0%
Protractor	10%
Plumb Bob	2%
String	0%
Hand Clamp	0%

the Condition Ratings alone are analyzed. Second, the correlation of the human and environmental factors measurements with the Condition Ratings are presented.

5.2.3.1. GENERAL ANALYSIS

The general analysis presented in this section uses common statistical methods to identify trends in the primary element Condition Ratings. In addition, the trends from the sample Condition Ratings are also extrapolated to the population.

5.2.3.1.1. Basic Statistical Task Information

The following presents the basic statistical analysis of the Condition Ratings assigned to the primary elements during the Routine Inspection tasks. Tables 71 through 76 provide the following information: the reference rating for each element as was described previously, the average Condition Rating from the sample, the standard deviation from the sample, the Coefficient of Variation (COV) (standard deviation divided by the average) from the sample, the

Table 70. Task G – Quantitative post-task question responses.

	Range of Possible Answers		Inspector Response			
	Low	High	Average	Standard Deviation	Maximum	Minimum
How similar were these inspection tasks to the tasks performed in your normal Routine Inspections?	1 = not similar	9 = very similar	6.8	2.5	9	1
Did this task do an accurate job of measuring your inspection skills?	1 = not accurate	9 = very accurate	6.7	2.0	9	1
How rested are you?	1 = very tired	9 = very rested	7.1	1.3	9	4
How well did you understand the instructions you were given?	1 = very poorly	9 = very well	8.5	0.8	9	5
How accessible do you feel the various bridge components were?	1 = very inaccessible	9 = very accessible	4.1	2.3	9	1
How well do you feel that this bridge has been maintained?	1 = very poorly	9 = very well	7.0	1.1	9	4
How complex was this bridge?	1 = very simple	9 = very complex	5.9	1.5	9	1
Do you think my presence as an observer had any influence on your inspection?	1 = no influence	9 = great influence	1.7	1.2	6	1
Did you feel rushed while completing this task?	1 = not rushed	9 = very rushed	1.7	1.2	6	1
What was your effort level on this task in comparison with your normal effort level?	1 = much lower	9 = much greater	5.2	1.0	7	1
How thorough were you in completing this task in comparison to your normal inspection?	1 = less thorough	9 = more thorough	4.9	1.5	8	1

minimum and maximum Condition Ratings, the mode (i.e., the most common Condition Rating), and the number of inspectors assigning Condition Ratings for each element for Tasks A, B, C, D, E, and G, respectively. Note that not all inspectors gave Condition Ratings for all elements, resulting in the number of inspectors assigning Condition Ratings for the element being less than the total number of participating inspectors. Figures 55 through 60 illustrate the frequency with which the inspectors gave individual Condition Ratings to each element for each task.

Table 71. Task A – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	5	5	6
Average	5.8	5.9	6.1
Standard Deviation	0.81	0.78	0.79
COV	0.14	0.13	0.13
Minimum	3	4	3
Maximum	7	8	7
Mode	6	6	6
N	49	49	49

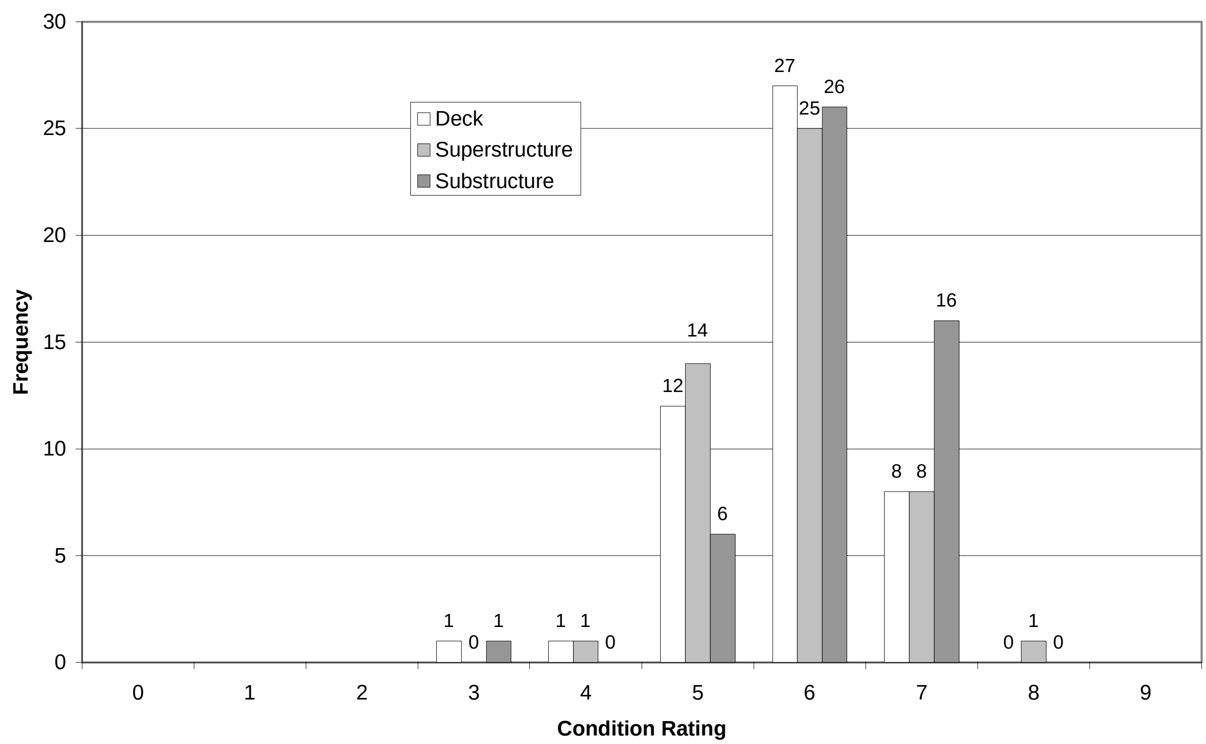


Figure 55. Task A – Condition Rating frequency distribution.

Table 72. Task B – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	4	4	4
Average	4.9	4.2	4.3
Standard Deviation	0.94	0.77	0.76
COV	0.19	0.18	0.18
Minimum	2	2	3
Maximum	7	6	6
Mode	5	4	4
N	48	49	49

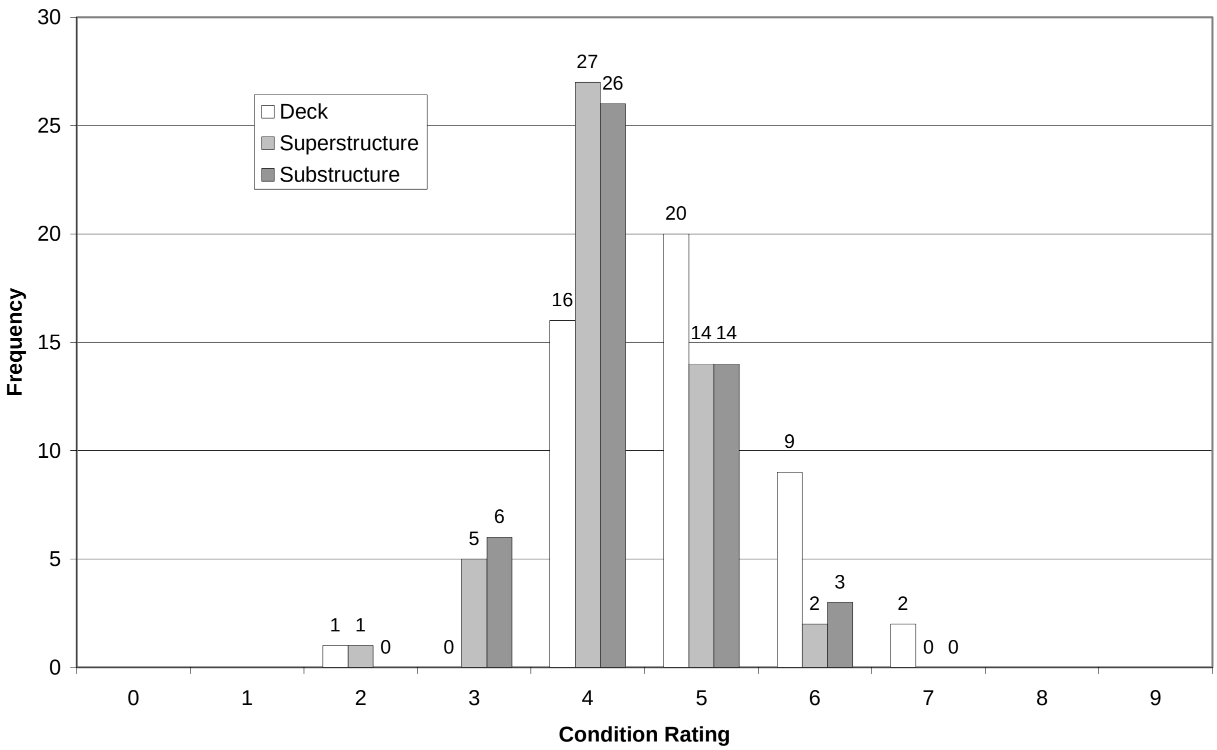


Figure 56. Task B – Condition Rating frequency distribution.

Table 73. Task C – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	4	4	5
Average	5.2	4.6	5.5
Standard Deviation	0.92	0.86	0.77
COV	0.18	0.19	0.14
Minimum	3	2	4
Maximum	7	7	7
Mode	6	5	5 and 6
N	49	49	48

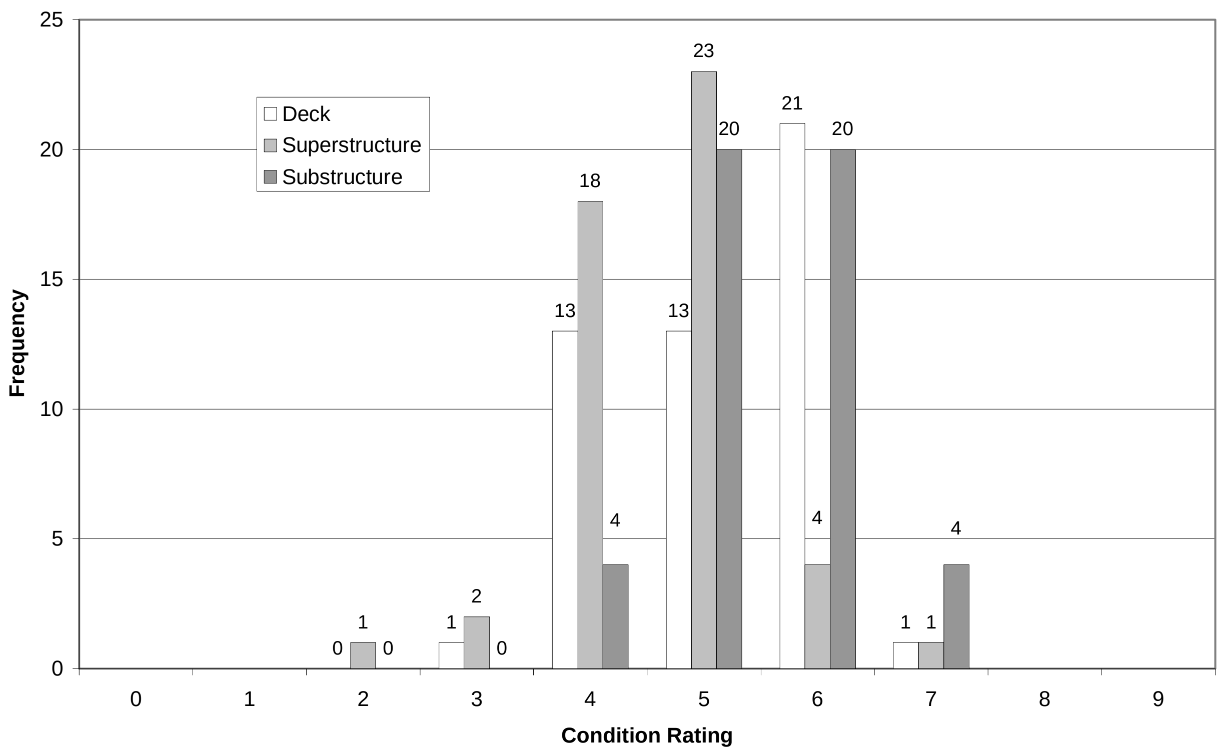


Figure 57. Task C – Condition Rating frequency distribution.

Table 74. Task D – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	5	5	6
Average	4.8	5.3	6.1
Standard Deviation	0.94	0.88	0.89
COV	0.19	0.17	0.15
Minimum	2	4	4
Maximum	6	7	8
Mode	5	5	6
N	48	44	47

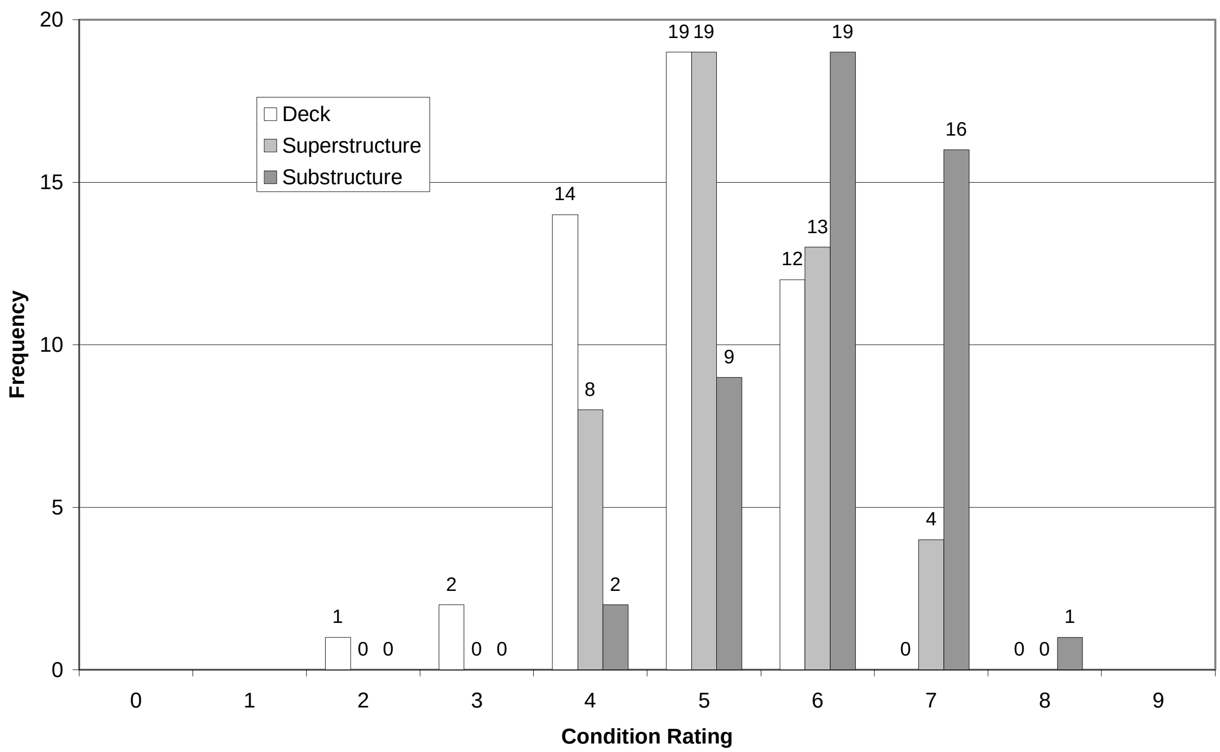


Figure 58. Task D – Condition Rating frequency distribution.

Table 75. Task E – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	4	6	6
Average	4.5	5.8	5.3
Standard Deviation	0.74	0.72	0.83
COV	0.16	0.13	0.16
Minimum	3	4	3
Maximum	6	7	7
Mode	5	6	5
N	48	48	47

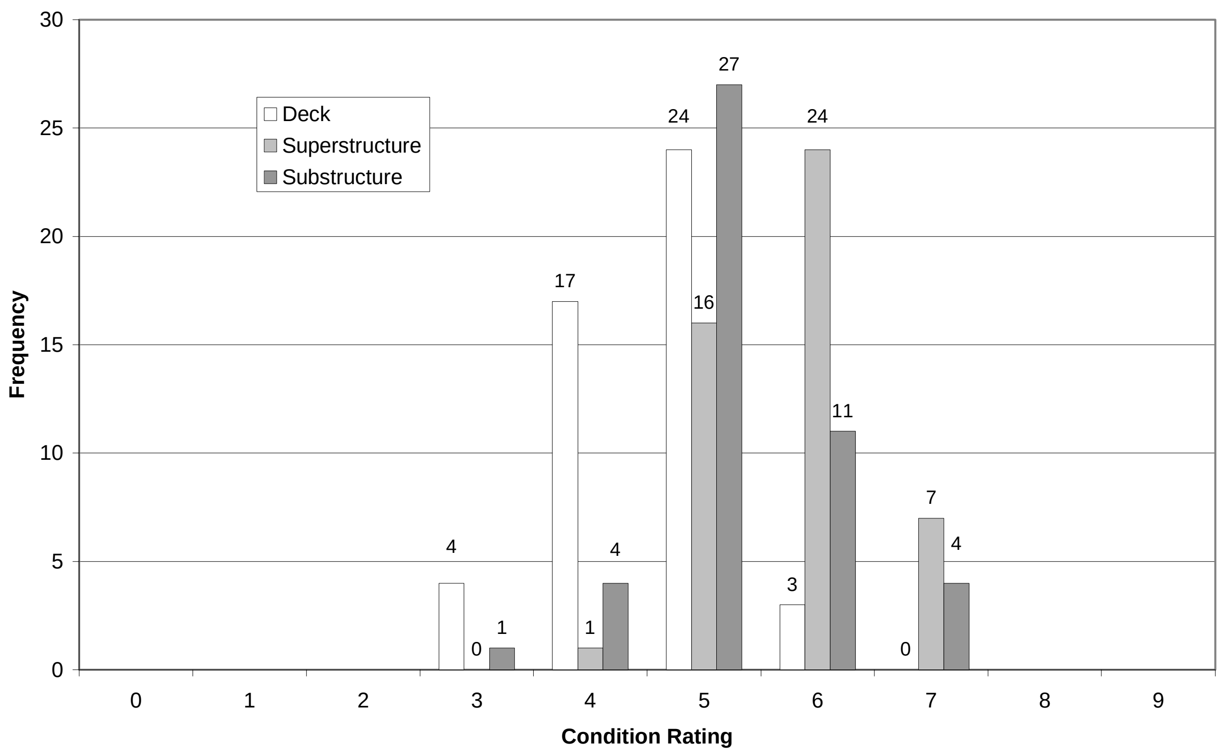


Figure 59. Task E – Condition Rating frequency distribution.

Table 76. Task G – Basic statistical information.

	Primary Element		
	Deck	Superstructure	Substructure
Reference	7	7	8
Average	7.1	6.7	7.2
Standard Deviation	0.53	0.66	0.57
COV	0.08	0.10	0.08
Minimum	6	5	6
Maximum	8	8	8
Mode	7	7	7
N	49	49	49

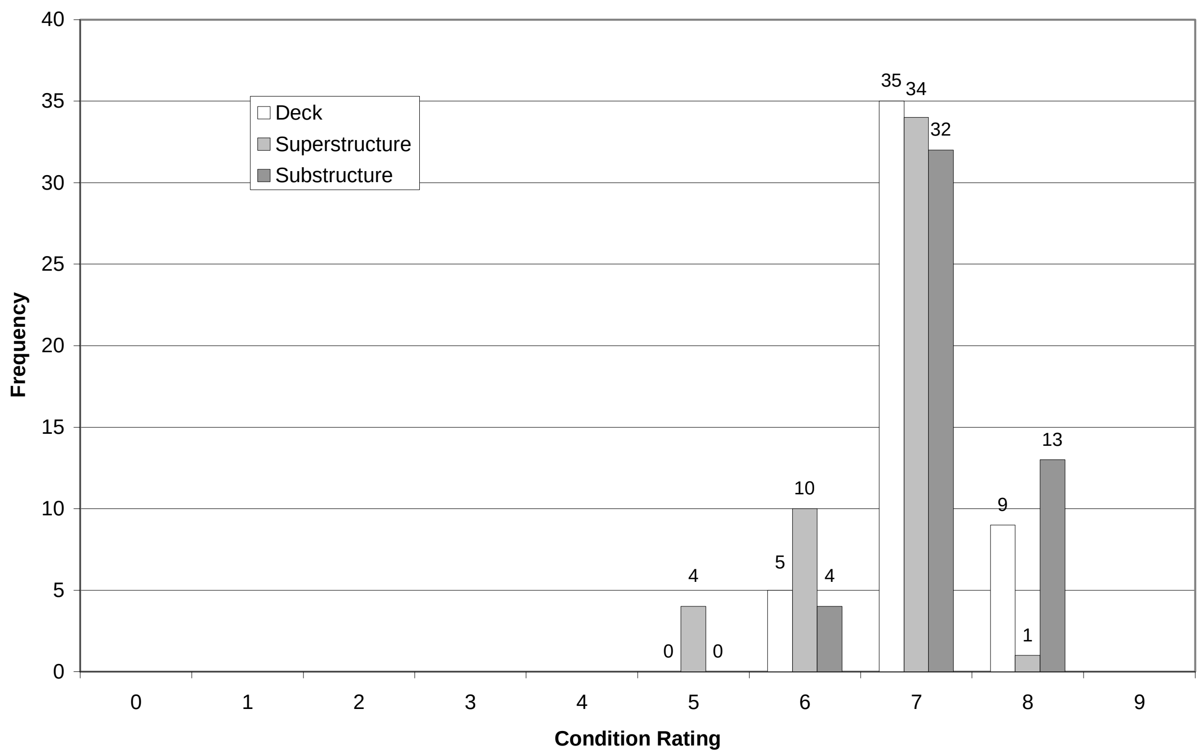


Figure 60. Task G – Condition Rating frequency distribution.

These data are the foundation for the analyses and discussion in the following sections. However, prior to the formal presentation that follows, some general trends in the data are mentioned here. First, the standard deviation for each primary element, in every task, is at least 0.53, illustrating the level of dispersion of the inspection results about the mean. In all, the average Condition Ratings for 13 of the primary elements are greater than the reference ratings, and for 5 of the elements, the Condition Ratings are less than the reference ratings. On average, there are between four and five different Condition Rating values assigned to each primary element, with a minimum of three and a maximum of six.

In order to determine if the average inspector Condition Ratings were statistically different from the reference ratings, the t-test was applied. For these analyses, the t-test was used as a statistical tool to test the null hypothesis that the sample average is equal to some value on the basis of a random sample. Table 77 summarizes the results of the t-test at a 5 percent significance level. "Fail" indicates that the data failed the t-test, meaning that the average Condition Rating was found to be different from the reference Condition Rating at the 5 percent significance level. "Pass" indicates that the data passed the t-test, thus the average Condition Rating and the reference Condition Rating cannot be considered different at a 5 percent significance level. From this table, it is apparent that, in most cases, the average inspector Condition Rating is different from the reference Condition Rating, with at least a 95 percent probability. The inspector Condition Ratings and the reference Condition Ratings are the data used in the discussion in the following sections.

Table 77. The t-test results at 5 percent significance level for the average Condition Ratings.

	Task					
Element	A	B	C	D	E	G
Deck	Fail	Fail	Fail	Pass	Fail	Pass
Superstructure	Fail	Fail	Fail	Fail	Fail	Fail
Substructure	Pass	Fail	Fail	Pass	Fail	Fail

Although the strict numerical difference between the reference and the average Condition Ratings discussed above may appear to be small, in many cases, the amount of difference that is statistically significant cannot be estimated without considering the size and distribution of the sample. Statistical significance in this context refers to how much of a deviation the reference and average Condition Ratings can have and still be attributed to random variations in the sample. Figure 61 shows the relationship of the sample size and distribution with the minimum amount of deviation from the actual condition that is statistically significant. The figure does so for two different standard deviations. These standard deviations are the bounds of the standard deviations observed in this study. This information is based on the t-test at a 5 percent significance level by backcalculating the maximum difference between the average and the reference for statistical insignificance. In terms of statistical significance, the figure shows that as the number of inspectors increases, the allowable deviation of the average Condition Rating from the actual Condition Rating decreases. As an example, if five inspectors were to assign Condition Ratings for a specific structure with a standard deviation of 0.53, the maximum amount that the average Condition Rating could deviate from the actual condition and still be considered statistically correct is 0.66. Similarly, although not shown in figure 61, if two inspectors assigned Condition Ratings for a structure, a difference larger than 4.8 rating points would be necessary for the average to be incorrect. This analysis illustrates why, although the numerical differences between the average and reference Condition Ratings in this study may appear small, knowledge of the sample size and dispersion is also necessary to determine whether the average Condition Ratings are statistically different from the reference ratings. The sample of inspectors in this analysis varied between 44 and 49, depending on the task. This results in an allowable deviation from the actual Condition Rating of between 0.14 and 0.27 rating points, depending on the task and the element type.

In order to draw conclusions from the above discussion concerning the accuracy of inspector Condition Ratings, one must assume a correct Condition Rating. In order to avoid making such an assumption, a second analysis was performed to ascertain Condition Rating accuracy without requiring that a correct Condition Rating be assumed. This analysis is again based on the t-test for statistical significance. In this analysis, the maximum allowable deviation from the correct Condition Rating was calculated from the t-statistic based on the sample size, sample distribution, and the appropriate maximum t-value. From this, one can determine the maximum deviation from the actual Condition Rating, Δ, that could be considered statistically insignificant

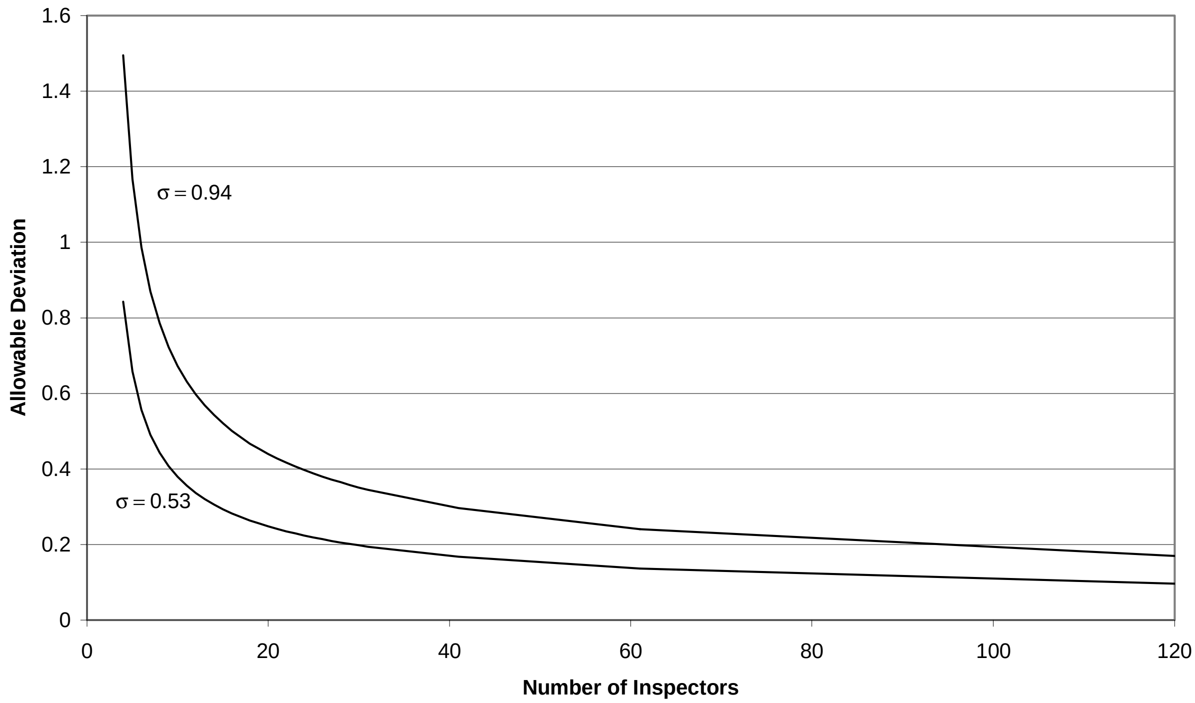


Figure 61. Influence of sample size and distribution on allowable deviation.

(or similarly, the minimum deviation from the actual that could be considered statistically significant). Then, using that deviation, the average Condition Rating for each element for each task was checked to see if it fell within that amount of the 10 Condition Ratings (i.e., 0, 1, 2,…,9). If the average did not fall within Δ for any discrete Condition Rating (i.e., $0 \pm\Delta$, $1 \pm\Delta$, $2 \pm\Delta$,…,$9\pm\Delta$), one can conclude that the average Condition Rating *is* statistically incorrect. If the Condition Rating did fall within Δ of a discrete Condition Rating, one could say that the average Condition Rating *may* be correct. Note that one can only say that the average *may* be correct, because for this to be true, one must assume that the correct Condition Rating is the one within Δ of the average Condition Rating. From this analysis, the following results were found.

- At least 56 percent of the average Condition Ratings are incorrect with a 95 percent probability.
- At least 22 percent of the average Condition Ratings are incorrect with a 99 percent probability.

- If the NDEVC reference ratings are correct, then 78 percent of the average Condition Ratings are incorrect with a 95 percent probability.
- If the NDEVC reference ratings are correct, then 56 percent of the average Condition Ratings are incorrect with a 99 percent probability.

The previous analysis looked at the overall accuracy of Condition Rating assignment for the sample. One could also analyze the accuracy on an individual inspector basis. In this analysis, one must assume that a bridge element only has one correct Condition Rating (e.g., a bridge cannot be an “8” (no problems noted) and a “7” (some minor problems) at the same time). With this assumption in mind, one can determine the maximum percentage of individual Condition Ratings that could possibly have been correct. This is done by calculating the maximum percentage of inspectors that gave a single Condition Rating for each component in each task. In a similar manner, one can also determine the maximum number of inspectors within one Condition Rating of the correct Condition Rating. Using this approach, the following results were obtained:

- At most, 52 percent of the individual Condition Ratings were assigned correctly.
- At least 48 percent of the individual Condition Ratings were assigned incorrectly.
- At most, 95 percent of the individual Condition Ratings were within one rating point of the correct Condition Rating.

For comparative purposes, the following results were determined assuming that the reference Condition Ratings are correct:

- If the reference Condition Ratings are correct, 42 percent of the individual Condition Ratings were assigned correctly.
- If the reference Condition Ratings are correct, 58 percent of the individual Condition Ratings were assigned incorrectly.
- If the reference Condition Ratings are correct, 89 percent of the individual Condition Ratings were within one point of the correct Condition Rating.

Given the large number of bridges in the National Bridge Inventory, it is possible that situations could arise in which two contiguous Condition Ratings could both describe the condition of a bridge element nearly equally well. In this case, it is likely that two Condition Ratings may each be assigned with a relatively high frequency. This could arise in at least two scenarios: (1) if the Condition Rating definitions are not refined enough to assign a single Condition Rating (e.g., the distinction between the definition of "6" (structural elements show minor deterioration) and "5" (all primary structural elements are sound but may have minor section loss, cracking, spalling, or scour") may not be great enough to always enable a clear differentiation) and (2) an element could have discrete regions with different levels of deterioration. In this situation, a rational assessment would give each area of the element a rating with a corresponding weighting factor based on the location of each area. These weighted conditions would then be combined to determine the Condition Rating. For example, if an element could be considered to be approximately 55 percent a "6" and 45 percent a "5", a rational assessment would give the element a "6". However, if one were to make the percentage assessments in a slightly different manner and arrive at 45 percent a "6" and 55 percent a "5", a rational assessment would give the element a "5". Although the two assessments are very close to one another, they each resulted in different Condition Ratings being assigned.

In situations like these, either of the two Condition Ratings could arguably be correct. Although it is not accurate to say that both Condition Ratings are correct, for this discussion, this situation will be referred to as the case where it is assumed that two Condition Ratings are correct. Based on this assumption, the following results were obtained. At most, 81 percent of the Condition Ratings could be considered correct if one assumes that two correct Condition Ratings could exist. Conversely, at least 19 percent of the Condition Ratings must be considered incorrect based on this scenario.

The previous discussion focused on assessing the accuracy of the primary element Condition Ratings independent of other influences. Figures 62 through 64 show the relationship of the maximum percentage of correct Condition Ratings with the reference, mode, and average Condition Ratings, respectively. These figures illustrate the correct Condition Ratings rate for the two situations described previously. Type 1 indicates the case when a single correct

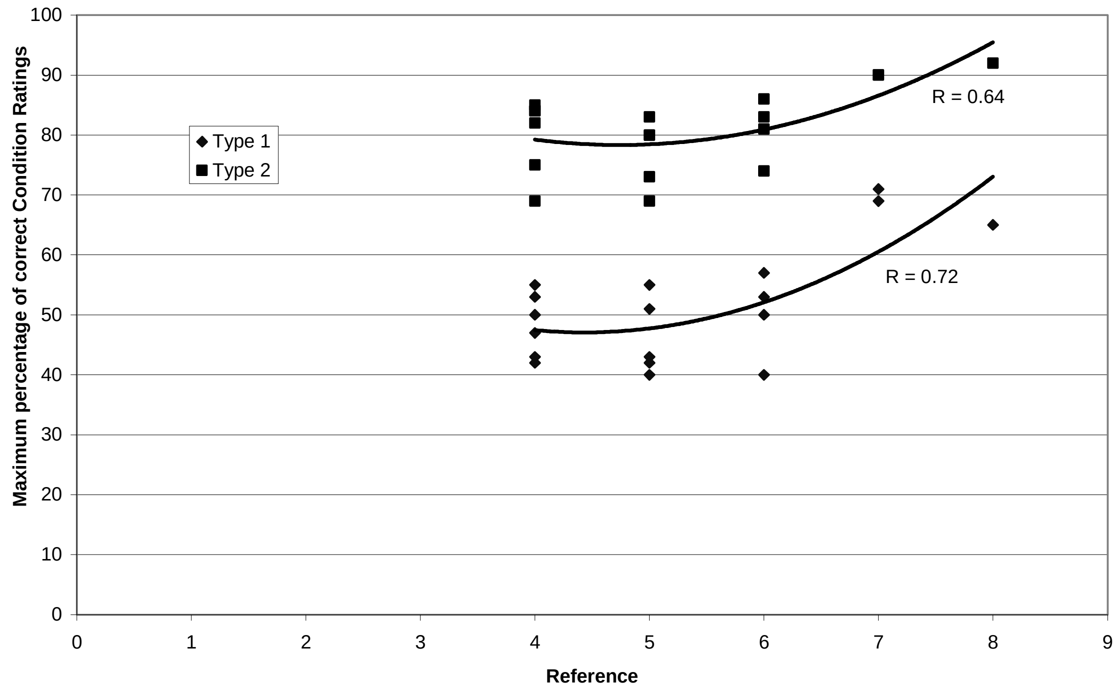


Figure 62. Relationship between Condition Rating accuracy and reference Condition Rating.

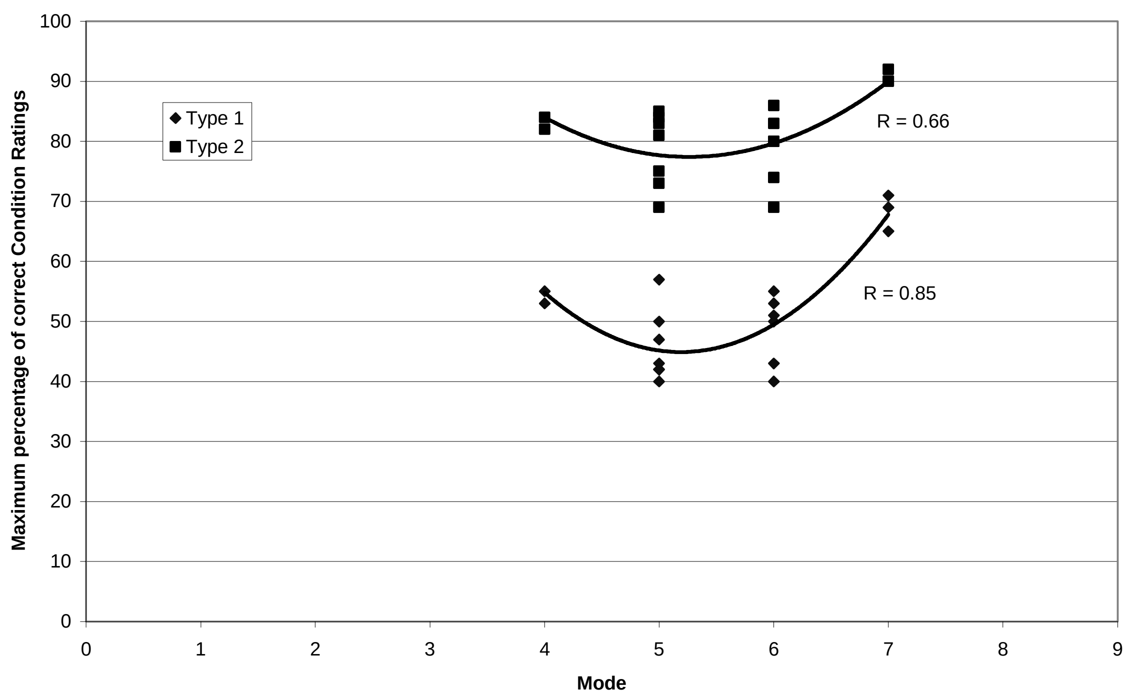


Figure 63. Relationship between Condition Rating accuracy and mode Condition Rating.

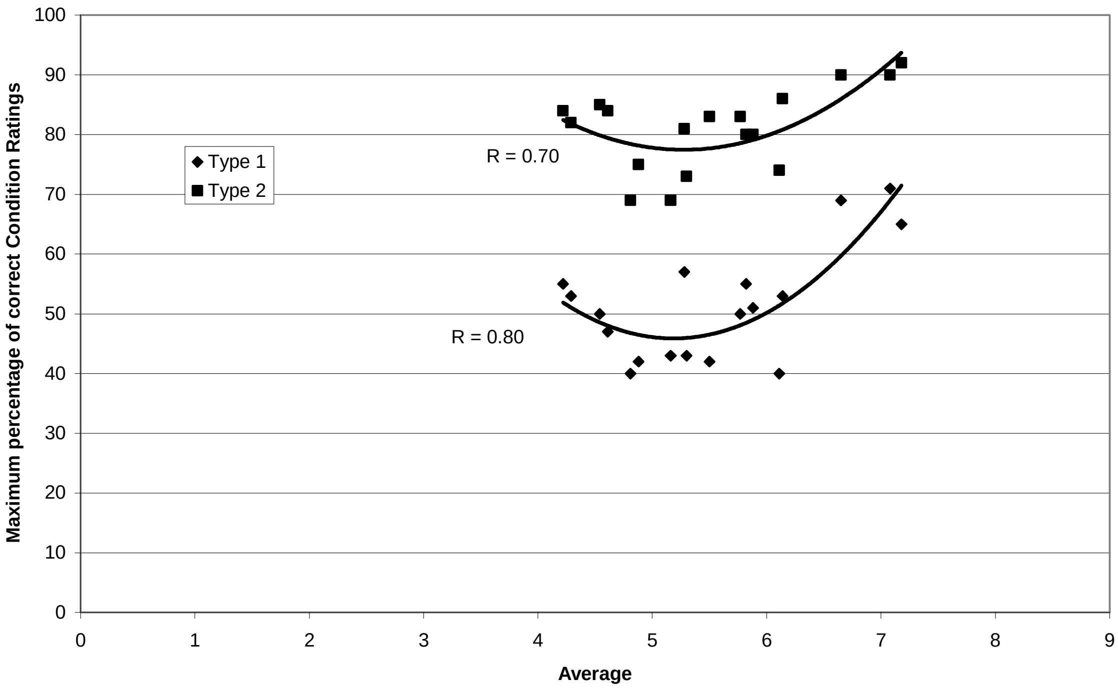


Figure 64. Relationship between Condition Rating accuracy and average Condition Rating.

Condition Rating is assumed and Type 2 indicates the case where two correct Condition Ratings are assumed. From these figures, it can be observed that regardless of the Condition Rating used for comparison, the poorer condition bridge elements within the study bridge component sample were assigned fewer correct Condition Ratings. This is probably attributable to inspector difficulties in defining the level of deterioration in terms of the verbiage used in the Condition Rating system.

5.2.3.1.2. Distribution of Experimental Population

The variations over the sample of inspection results are the cornerstone for drawing many conclusions. Although direct extrapolation of the sample distribution to the population of State bridge inspectors may not be statistically valid, the experimental distribution is nevertheless insightful.

Table 78 summarizes the distribution of the sample about three statistically or physically meaningful benchmarks. The first benchmark is the reference condition rating. This rating is an important benchmark because it represents the Condition Rating established by the NDEVC that

Table 78. Distribution of sample Condition Ratings.

Task	Element	Reference	Average	Mode	Percentage of Sample Within ± 1 of Reference	± 2 of Reference	± 1 of Average	± 2 of Average	± 1 of Mode	± 2 of Mode
A	Deck	5	5.8	6	82	100	80	98	96	98
	Superstructure	5	5.9	6	82	98	80	98	96	100
	Substructure	6	6.1	6	98	98	86	98	98	98
B	Deck	4	4.9	5	75	96	75	94	94	98
	Superstructure	4	4.2	4	94	100	84	98	94	100
	Substructure	4	4.3	4	94	100	82	100	94	100
C	Deck	4	5.2	6	55	98	69	98	71	98
	Superstructure	4	4.6	5	88	98	84	96	92	98
	Substructure	5	5.5	5,6	92	100	83	100	92	100
D	Deck	5	4.8	5	94	98	69	98	94	98
	Superstructure	5	5.3	5	91	100	73	100	91	100
	Substructure	6	6.1	6	94	100	74	96	94	100
E	Deck	4	4.5	5	94	100	85	100	92	100
	Superstructure	6	5.8	6	98	100	83	100	98	100
	Substructure	6	5.3	5	89	98	81	98	89	100
G	Deck	7	7.1	7	100	100	90	100	100	100
	Superstructure	7	6.7	7	92	100	90	100	92	100
	Substructure	8	7.2	7	92	100	92	100	100	100

is believed to be the “actual” Condition Rating. The second benchmark, the average Condition Rating, gives a description of the central tendency of the sample Condition Ratings. Finally, the mode is the peak value of a frequency diagram. It provides a rough measure of central tendency and is the inspector consensus on the Condition Ratings.

The data presented in table 78 are the percentage of the sample that are within one or two rating points from the reference, average, and mode Condition Ratings. When comparing these data to the reference values, it becomes apparent that approximately 90 percent of the Condition Ratings are within one point of the reference. In addition, approximately 99 percent of the Condition Ratings are within two rating points and all of the Condition Ratings are within three rating points of the reference.

The distribution of the Condition Ratings about the average shows greater variability than the distribution about the reference. However, this decrease in consistency may not accurately describe the distribution. The apparent drop stems from the type of data that was collected (i.e., only integer Condition Ratings). As an example, if the Task G deck Condition Ratings are compared to the reference value, 100 percent are within one rating point, whereas when compared to the average, only 90 percent are within one rating point. This results from the fact that when compared to the reference value, Condition Ratings 6, 7, and 8 were used to compute the percentage. However, when compared to the average value, only Condition Ratings in the range from 6.1 to 8.1 (i.e., 7 and 8) were used.

In order to avoid this phenomenon, one could use the mode as the central tendency measure. The results of these analyses are summarized in table 78. The distribution about the mode data shows a similar, but slightly smaller, distribution when compared to the distribution about the reference values.

Regardless of the value used for the analysis, most inspection results had a relatively narrow distribution. The one exception to this occurred in the evaluation of the Task C deck. This can probably be attributed to the fact that approximately 20 percent of the Task C deck had a relatively new wearing surface. This may have resulted in inconsistencies in the inspector assessments.

Table 79 shows the distribution of the deviation from reference (DFR) data for all tasks. The DFR is calculated as the inspector rating minus the reference rating. By completing this simple arithmetic manipulation, Condition Ratings from multiple tasks can rationally be combined. The data set used to develop table 79 is the DFR from each inspector and shows the percentage of Condition Ratings that are within a zero DFR, the average DFR, and the mode DFR. It should be pointed out that tables 78 and 79 give similar information. The difference is that the data in table 78 gives the percentage of inspector Condition Ratings about three benchmark Condition Ratings, whereas table 79 gives the percentage of inspector DFRs about three benchmark DFRs.

Table 79. Distribution of sample DFRs.

Element	Average DFR	Mode DFR	Percentage of Sample Within ± 1 of Zero DFR	± 2 of Zero DFR	± 1 of Average DFR	± 2 of Average DFR	± 1 of Mode DFR	± 2 of Mode DFR
All Decks	0.55	0	83	99	75	97	83	99
All Superstructures	0.24	0	91	99	76	97	91	99
All Substructures	-0.08	0	93	99	69	97	93	99
All Elements	0.24	0	89	99	72	97	89	99

These data indicate that, overall, the average of the inspector Condition Ratings for the decks is 0.55 points higher than the reference, 0.24 points higher than the reference for the superstructures, and 0.08 points lower than the reference for the substructures. This resulted in an overall average DFR, regardless of the element type, that was 0.24 points higher than the reference rating.

5.2.3.1.3. Analytical Modeling and Theoretical Distribution of the General Population

Although much can be learned about the sample from the previous data, direct extrapolation of the data to the population is not statistically justifiable. One means of extrapolating a sample to a population is by using theoretical probability distributions based on data from the sample. From this type of analysis, it is possible to make statements regarding predicted results for the population. Theoretical probability distributions account for the natural variability in the sample and estimate how this variability would propagate into the population.

Because it occurs in many practical problems and has been widely studied, the normal, or Gaussian, distribution is one of the most commonly used theoretical distributions. This distribution is often referred to as one of the fundamentals of statistical analysis because of its widespread, natural occurrence. The general form of the normal distribution is given by Equation 1:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{1}$$

where:

μ = Sample mean

σ = Sample standard deviation

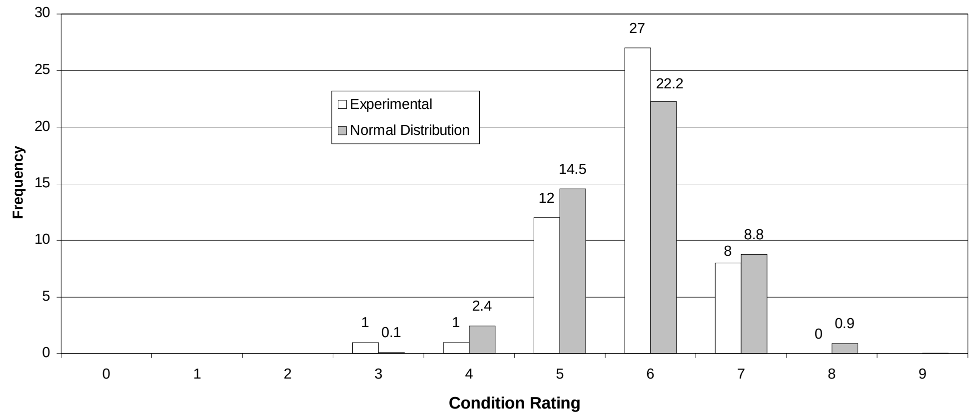
x = Value being distributed

$f(x)$ = Relative frequency

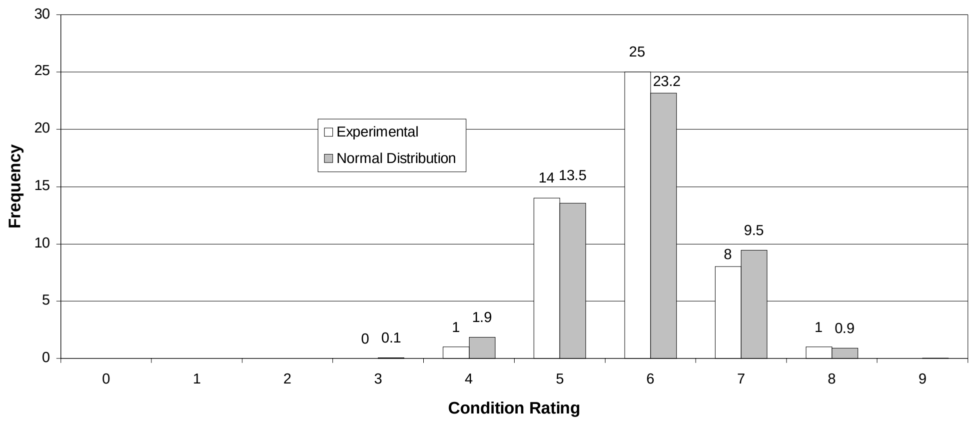
The normal distribution was used to analyze the Condition Rating results for each of the primary element Condition Ratings. The appropriateness of the distribution was then verified by applying the χ^2 test for goodness-of-fit. The χ^2 test revealed that all but one element of one task (the substructure for Task A) had a Condition Rating distribution that could be considered to be normally distributed. Figures 65 through 70 illustrate the relationship between the sample Condition Rating and the analytical (i.e., normal) Condition Rating distribution.

Based on the previous analyses, the sample Condition Ratings can be considered normally distributed. Thus, extrapolation from the sample to the population is considered valid. Accordingly, table 80 shows the range of Condition Ratings for each task where various percentages of the population are predicted to fall. The difference between these data and the experimental data presented earlier cannot be overemphasized. These data are not directly indicative of how the sample performed, but rather are an extrapolation to the population based on how the sample performed. It should be pointed out that the data in the 68 percent column simply represent a range of two times the sample standard deviations, the 95 percent data are a range of four times the sample standard deviation, and the 99 percent data represent a range of six times the sample standard deviation.

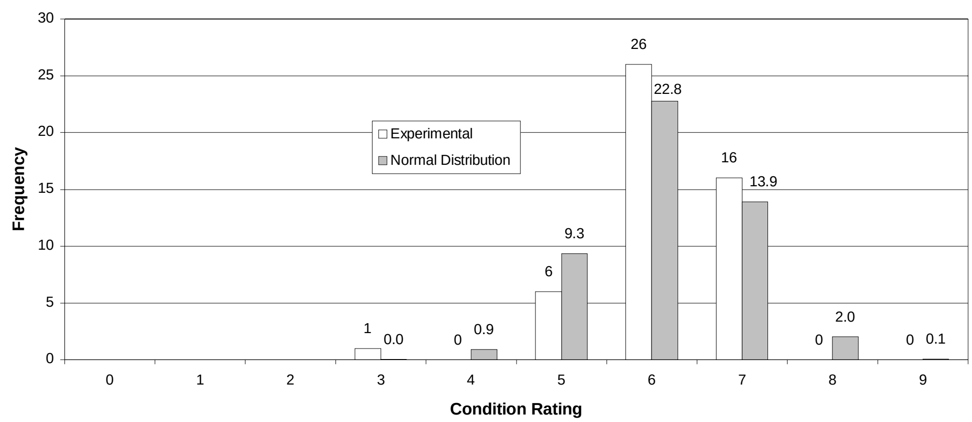
The data presented in table 80 are task- and element-specific and may not be very useful for general use. In this regard, data from all tasks were combined such that wider generalizations could be made. This was completed by combining the DFR data for all tasks. The properties of the combined data were then used to develop theoretical normal distribution frequencies that were again tested for goodness-of-fit. As before, these tests revealed that the distribution of the combined DFR data was normal (see figures 71 through 74). The products of these analyses are summarized in table 81. Typically, the theoretical value of 95 percent of the population is used



a. Deck

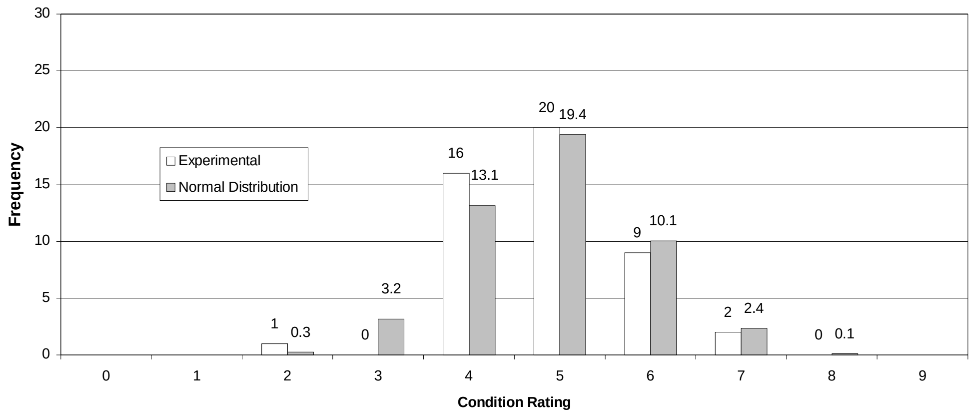


b. Superstructure

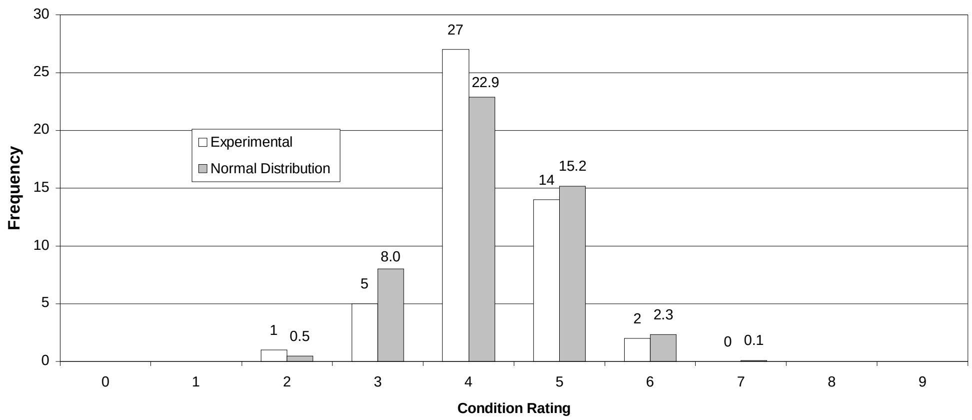


c. Substructure

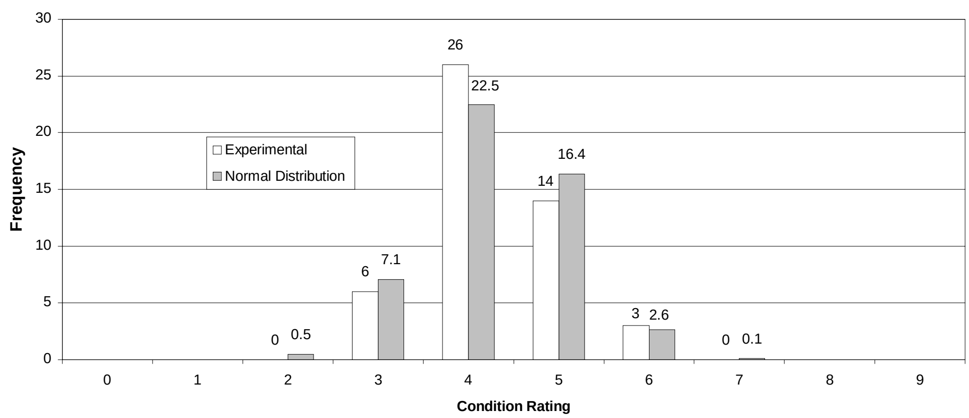
Figure 65. Task A experimental and theoretical Condition Rating distributions.



a. Deck

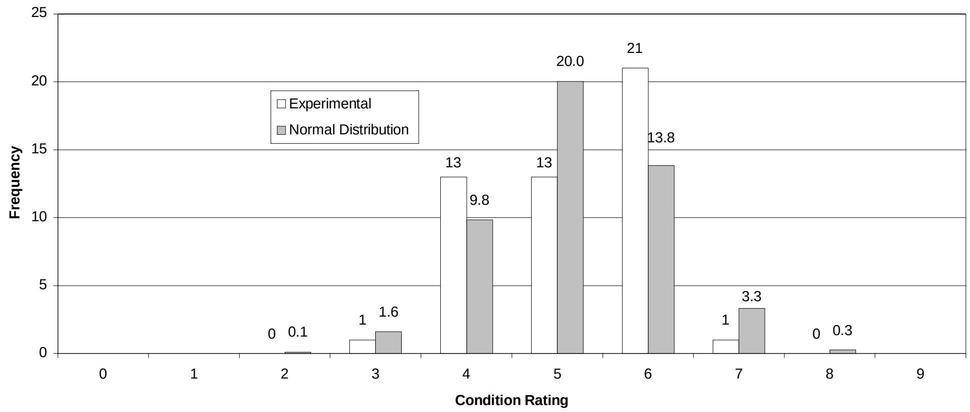


b. Superstructure

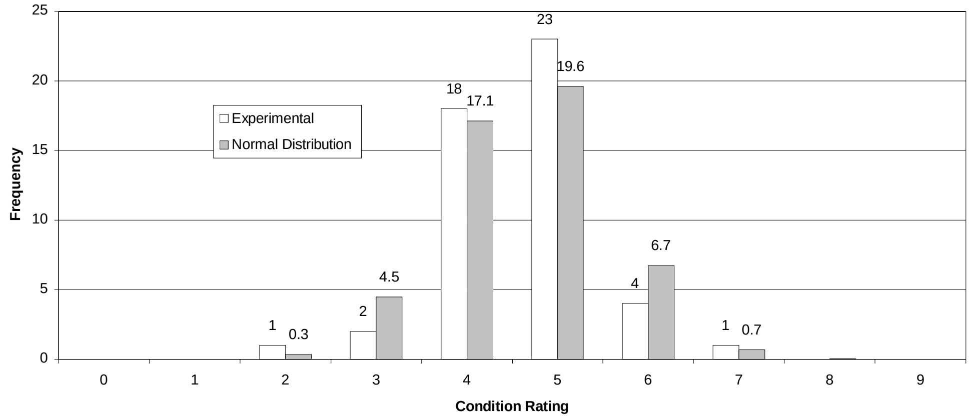


c. Substructure

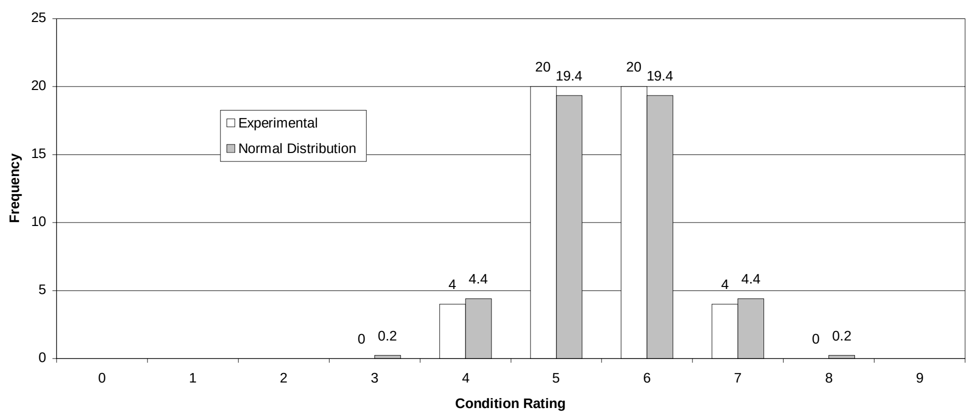
Figure 66. Task B experimental and theoretical Condition Rating distributions.



a. Deck

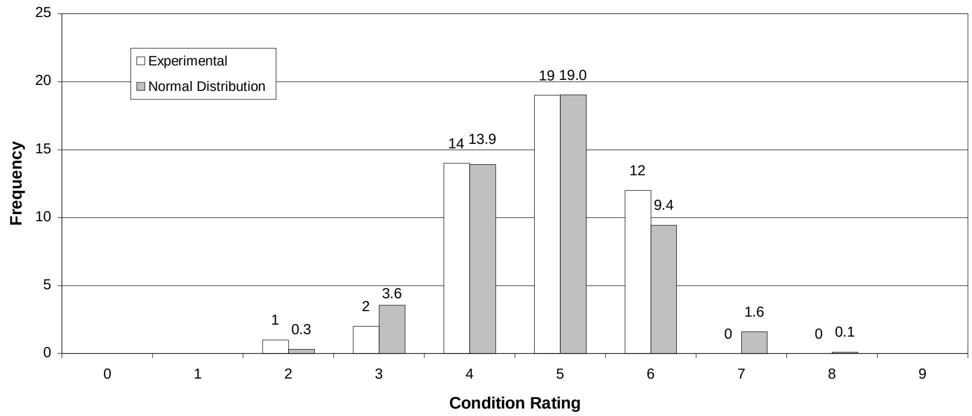


b. Superstructure

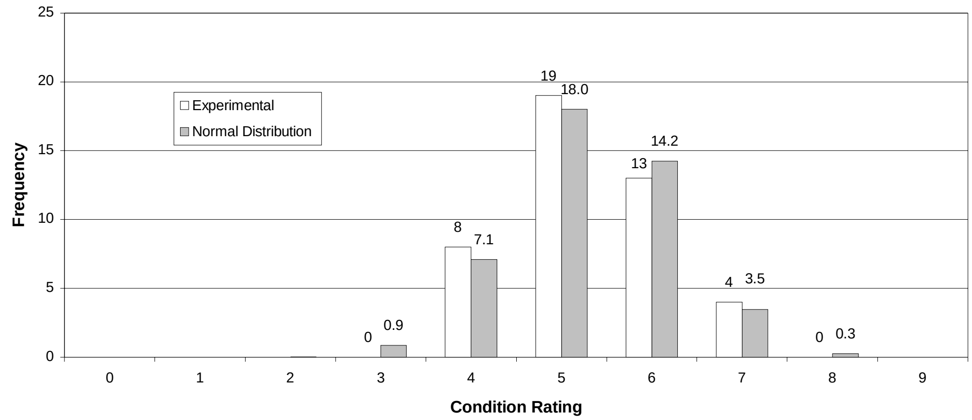


c. Substructure

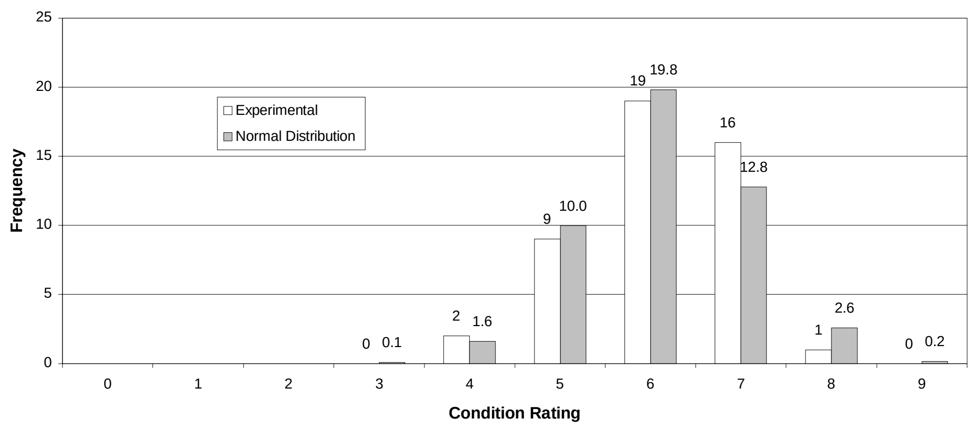
Figure 67. Task C experimental and theoretical Condition Rating distributions.



a. Deck

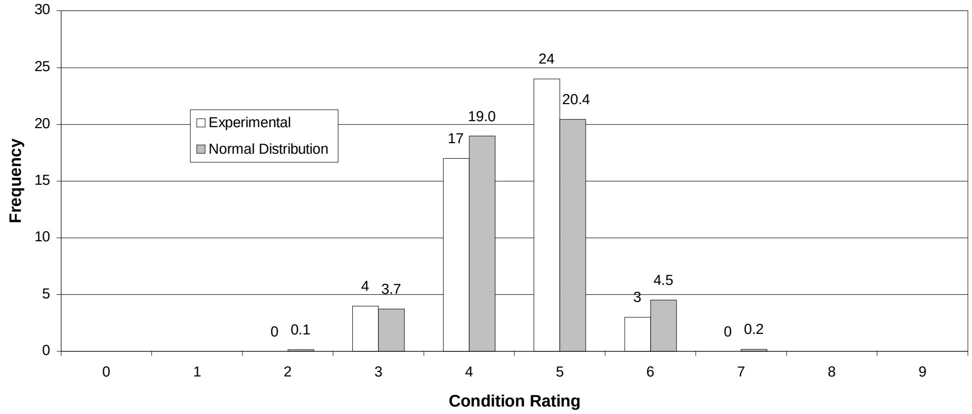


b. Superstructure

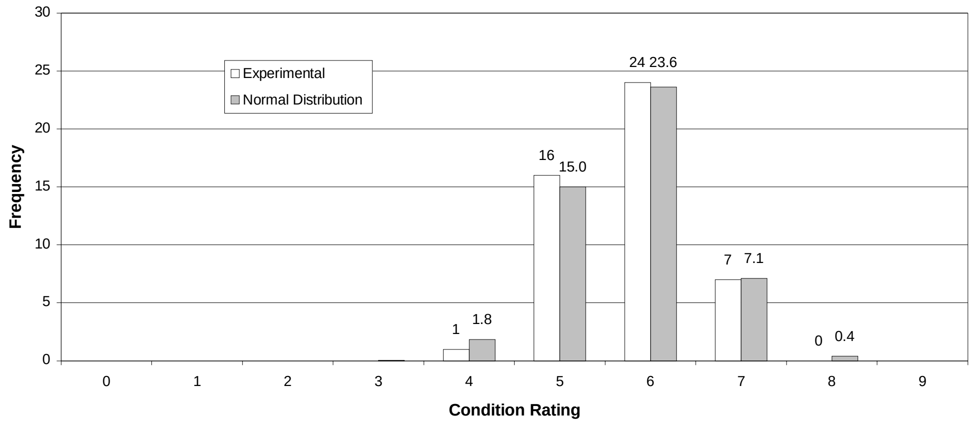


c. Substructure

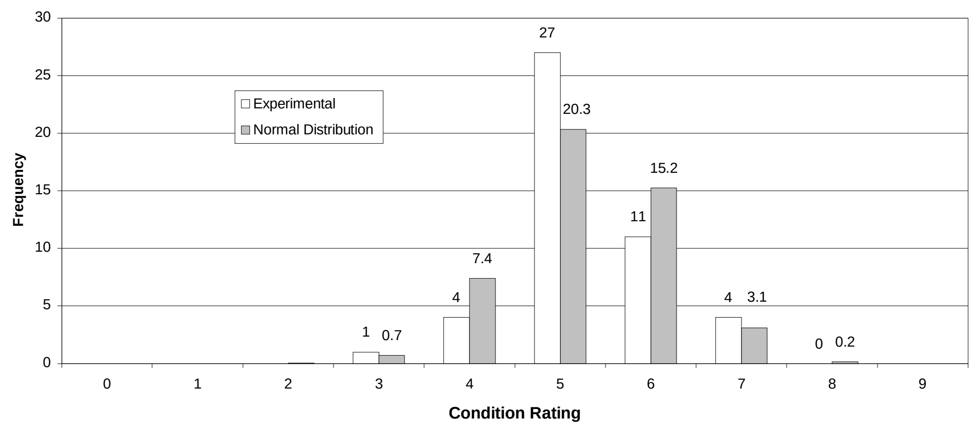
Figure 68. Task D experimental and theoretical Condition Rating distributions.



a. Deck

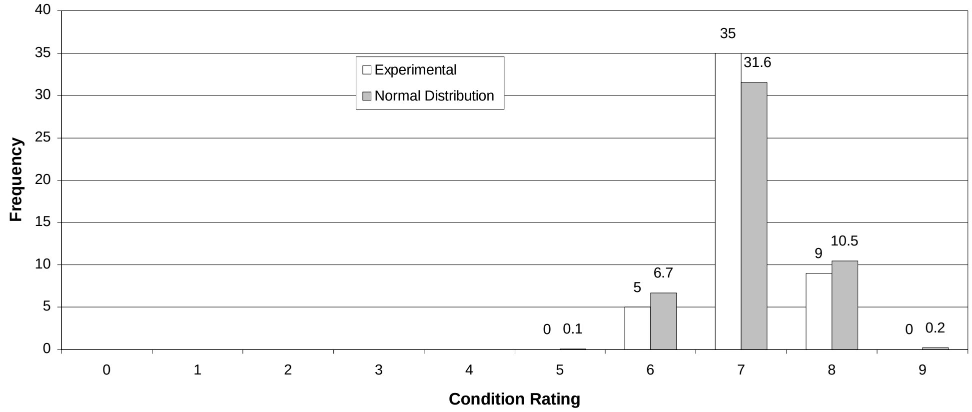


b. Superstructure

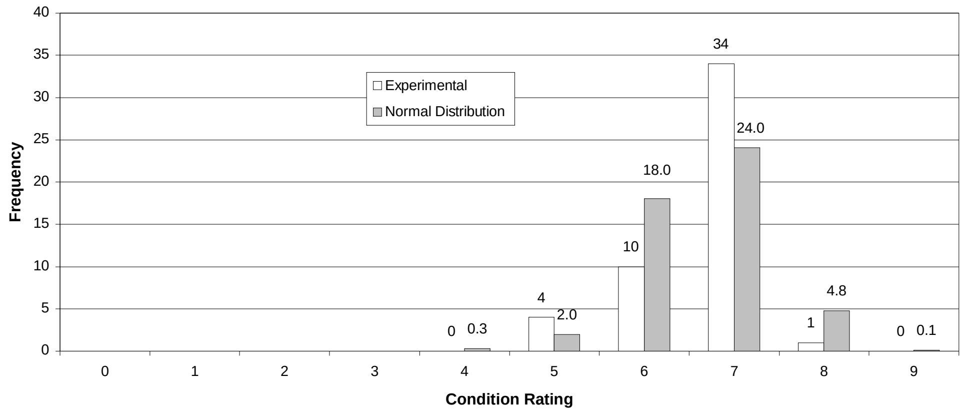


c. Substructure

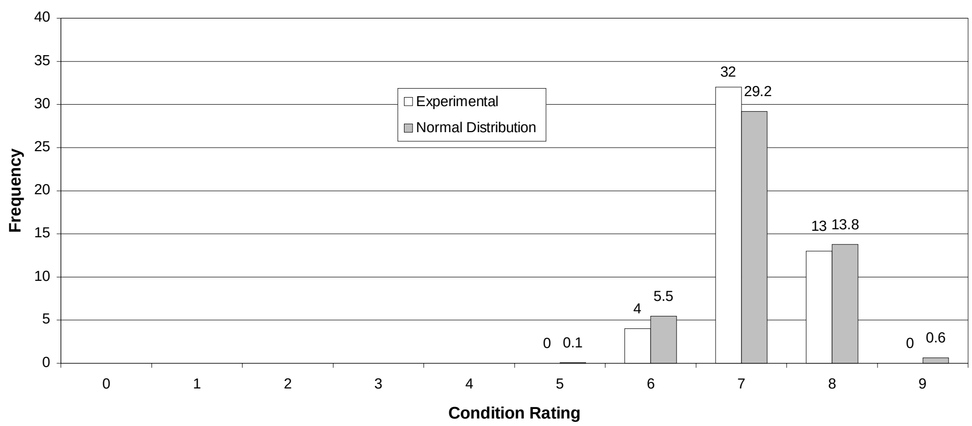
Figure 69. Task E experimental and theoretical Condition Rating distributions.



a. Deck.



b. Superstructure



c. Substructure

Figure 70. Task G experimental and theoretical Condition Rating distributions.

Table 80. Theoretical distribution of Condition Ratings.

Task	Element	Reference	Average	Predicted Condition Rating Ranges for Percentages of the Population		
				68%	95%	99%
A	Deck	5	5.8	5.0 to 6.6	4.2 to 7.4	3.4 to 8.3
	Superstructure	5	5.9	5.1 to 6.7	4.3 to 7.4	3.5 to 8.2
	Substructure*	6	6.1	5.4 to 6.9	4.6 to 7.7	3.8 to 8.5
B	Deck	4	4.9	3.9 to 5.8	3.0 to 6.8	2.1 to 7.7
	Superstructure	4	4.2	3.5 to 5.0	2.7 to 5.8	1.9 to 6.5
	Substructure	4	4.3	3.5 to 5.1	2.8 to 5.8	2.0 to 6.6
C	Deck	4	5.2	4.2 to 6.1	3.3 to 7.0	2.4 to 7.9
	Superstructure	4	4.6	3.8 to 5.5	2.9 to 6.3	2.0 to 7.2
	Substructure	5	5.5	4.7 to 6.3	4.0 to 7.0	3.2 to 7.8
D	Deck	5	4.8	3.9 to 5.8	2.9 to 6.7	2.0 to 7.6
	Superstructure	5	5.3	4.4 to 6.2	3.5 to 7.1	2.7 to 7.9
	Substructure	6	6.1	5.2 to 7.0	4.3 to 7.9	3.4 to 8.8
E	Deck	4	4.5	3.8 to 5.3	3.1 to 6.0	2.3 to 6.8
	Superstructure	6	5.8	5.1 to 6.5	4.3 to 7.2	3.6 to 7.9
	Substructure	6	5.3	4.5 to 6.1	3.6 to 6.9	2.8 to 7.8
G	Deck	7	7.1	6.6 to 7.6	6.0 to 8.1	5.5 to 8.7
	Superstructure	7	6.7	6.0 to 7.3	5.3 to 8.0	4.7 to 8.6
	Substructure	8	7.2	6.6 to 7.8	6.0 to 8.3	5.5 to 8.9

* Did not satisfy χ^2 test for goodness-of-fit.

Table 81. Theoretical distribution of DFR ranges.

Element	Average DFR	Predicted DFR Ranges for Percentages of the Population		
		68%	95%	99%
All Decks	0.55	-0.4 to 1.5	-1.3 to 2.4	-2.3 to 3.4
All Superstructures	0.24	-0.7 to 2.0	-1.5 to 2.0	-2.4 to 2.9
All Substructures	-0.08	-1.0 to 0.84	-1.9 to 1.8	-2.8 to 2.7
All Elements	0.24	-0.7 to 1.2	-1.7 to 2.1	-2.6 to 3.1

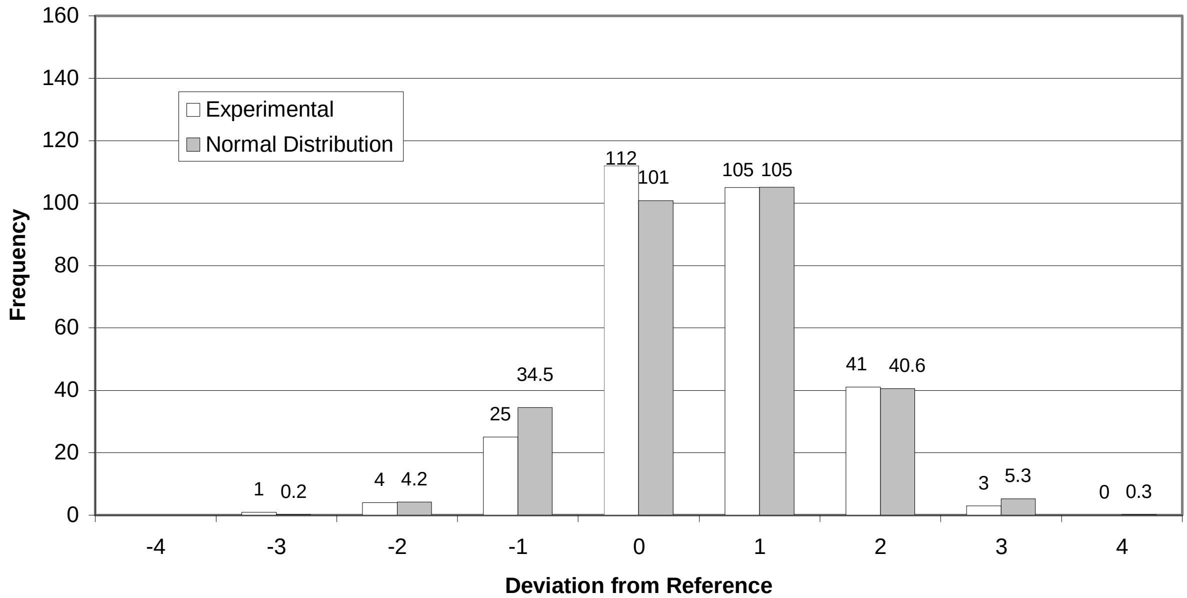


Figure 71. Experimental and theoretical DFR distributions – Deck.

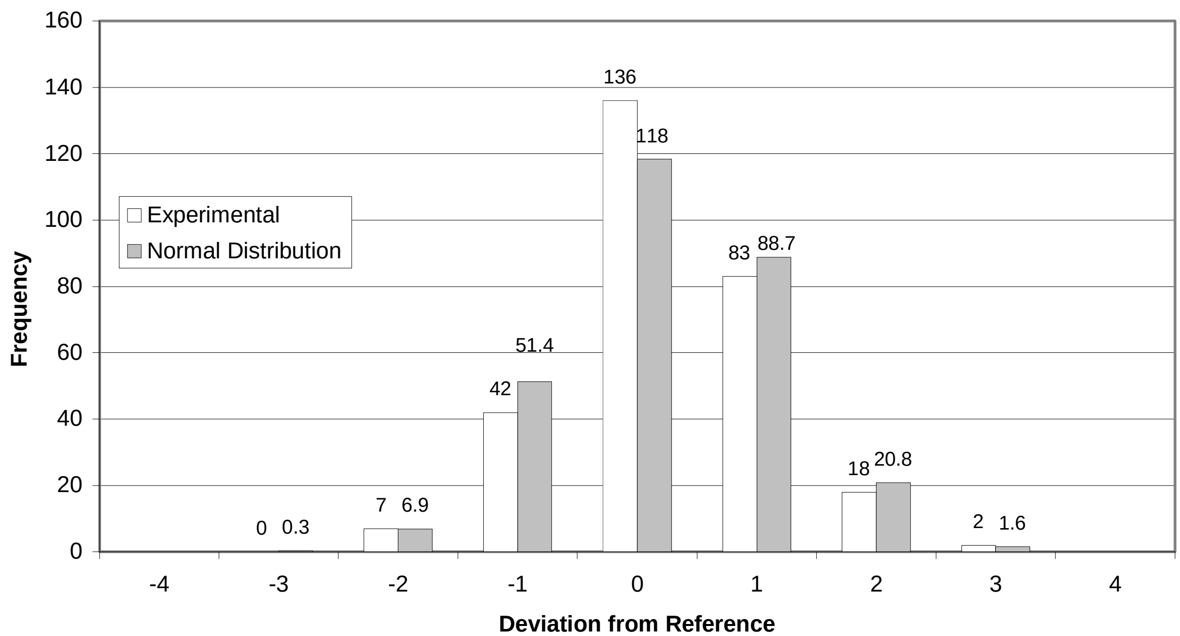


Figure 72. Experimental and theoretical DFR distributions – Superstructure.

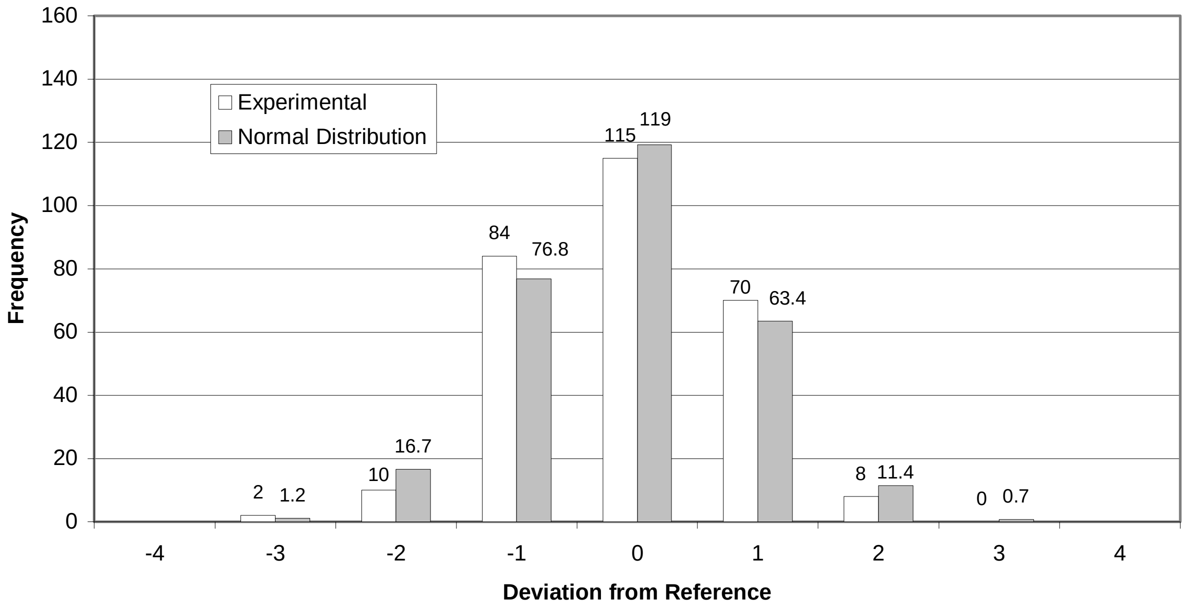


Figure 73. Experimental and theoretical DFR distributions – Substructure.

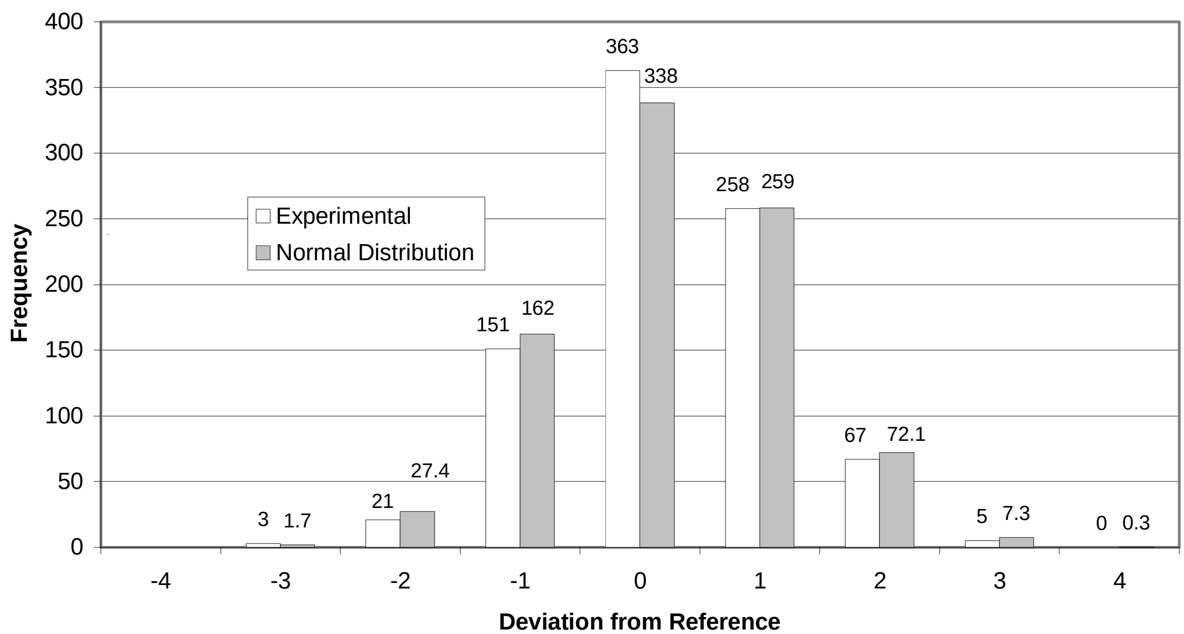


Figure 74. Experimental and theoretical DFR distributions – All element types.

to gauge predicted ranges of data because a 95 percent probability is typically viewed as an acceptable risk level. With this in mind, one can conclude that, in general, 95 percent of the Condition Ratings for a specific bridge will vary within approximately plus or minus two rating points from the average inspector Condition Rating for that bridge. In addition, note that approximately 68 percent of the Condition Ratings will be within approximately plus or minus one rating point of that average.

5.2.3.1.4. Influence of Primary Element Condition and Type on Condition Ratings

Variations in inspection results could be related to the overall condition and/or type of the element being inspected. In order to assess the relationship with element condition, the bridge elements were divided into two broad categories – "better" and "poorer." These categories are based on the reference Condition Rating assigned to each element. Components were assigned a "better" General Condition if they had a reference rating of 9 through 6 and a "poorer" General Condition if they had a reference rating of 5 through 0. Table 82 summarizes these classifications.

Table 83 presents a summary of the DFR data grouped by element type and General Condition. This table shows that the deck, regardless of the General Condition, was, on average, rated higher than the reference. Note, however, there was only one "better" condition deck and it was rated with the least DFR, as well as the least dispersion. Alternately, the "better" condition superstructures and substructures were rated lower than the reference, but to a lesser extent than the "poorer" condition superstructures and substructures were rated higher.

Table 83 also shows that the "poorer" condition elements were typically rated with the greatest dispersion, as illustrated by the standard deviation of the DFR data. The data also illustrate that, of the different element types, the superstructures were evaluated, overall, with the least dispersion. The maximum positive and maximum negative DFR data are also presented in table 83 for comparative purposes. These data illustrate the data spread and support the general trends given elsewhere.

Table 82. Classification of primary element General Condition.

Task	Element	Reference Condition Rating	General Condition
A	Deck	5	poorer
	Superstructure	5	poorer
	Substructure	6	better
B	Deck	4	poorer
	Superstructure	4	poorer
	Substructure	4	poorer
C	Deck	4	poorer
	Superstructure	4	poorer
	Substructure	5	poorer
D	Deck	5	poorer
	Superstructure	5	poorer
	Substructure	6	better
E	Deck	4	poorer
	Superstructure	6	better
	Substructure	6	better
G	Deck	7	better
	Superstructure	7	better
	Substructure	8	better

Table 83. DFR by component type and General Condition.

Element	General Condition	N	Average	Standard Deviation	Maximum Positive Deviation	Maximum Negative Deviation
Deck	poorer	5	0.64	0.98	3	-3
	better	1	0.08	0.53	1	-1
	all	6	0.55	0.94	3	-3
Superstructure	poorer	4	0.51	0.86	3	-2
	better	2	-0.29	0.69	2	-2
	all	6	0.24	0.80	3	-2
Substructure	poorer	2	0.39	0.77	2	-1
	better	4	-0.32	0.89	2	-3
	all	6	-0.08	0.92	2	-3
All	poorer	11	0.55	0.90	3	-3
	better	7	-0.25	0.80	2	-3
Overall		18	0.24	0.95	3	-3

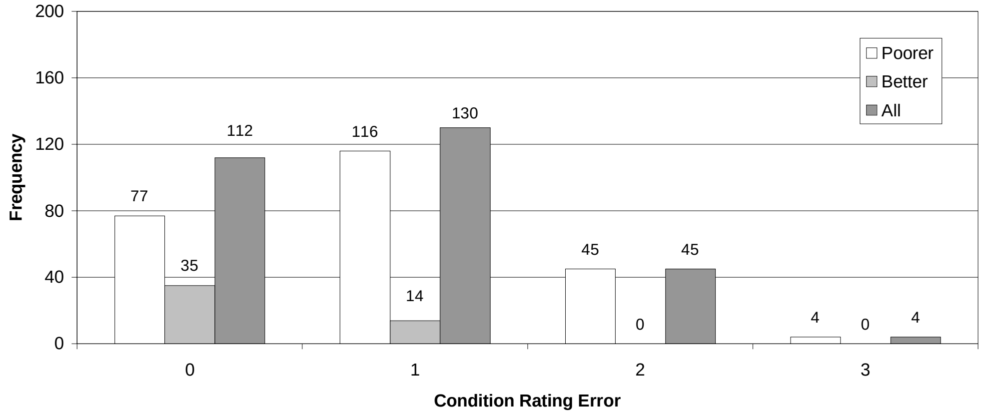
5.2.3.1.5. Influence of Primary Element Type and Conditions on Condition Rating Error

Some observations can be made from the Condition Rating errors. In this discussion, "Condition Rating error" is defined as the absolute value of the DFR data. This information is useful for bridge owners because it establishes how often and to what extent Condition Ratings vary from the reference rating, regardless of whether the deviation is negative or positive. Table 84 summarizes these data. From this table, it can be seen that "poorer" condition elements consistently exhibited the greatest error, as well as the largest dispersion of those errors. The "poorer" condition decks had both the largest average error and the largest dispersion of all element types, while the "better" condition deck had both the smallest average error and the smallest dispersion of all components. This indicates that inspectors may have the greatest difficulty in assessing the severity of the deficiencies in relatively more deficient bridge decks.

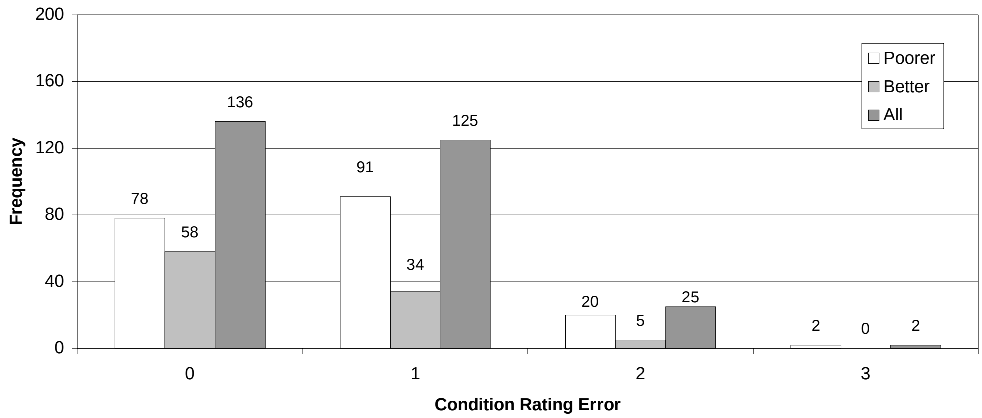
Table 84. Condition Rating error by component type and General Condition.

Element	General Condition	N	Average Error	Standard Deviation	Maximum	Mode
Deck	poorer	5	0.90	0.75	3	1
	better	1	0.29	0.46	1	0
	all	6	0.80	0.75	3	1
Superstructure	poorer	4	0.72	0.69	3	1
	better	2	0.45	0.60	2	0
	all	6	0.63	0.67	3	0
Substructure	poorer	2	0.60	0.62	2	0
	better	4	0.72	0.62	3	1
	all	6	0.68	0.62	3	1
All	poorer	11	0.78	0.72	3	1
	better	7	0.58	0.61	3	0
Overall		18	0.70	0.68	3	1

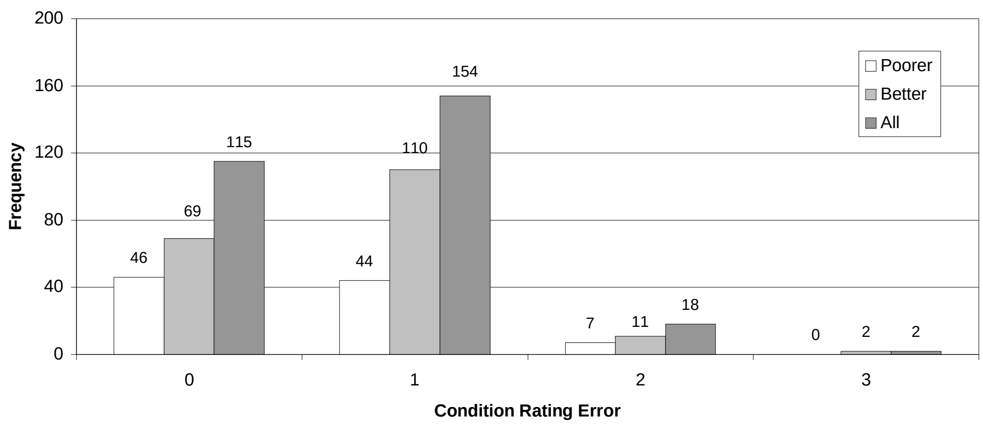
From table 84, it can also be seen that, overall, inspectors were most likely to give a Condition Rating with an error of 1 (i.e., either +1 or -1 from the reference). This is also shown in figures 75 and 76 that give the frequency distribution of the Condition Rating error data. These figures clearly indicate that the most common level of inspector error was providing a rating that was less than or equal to one point removed from the reference value. This further illustrates the accuracy of the sample.



a. Deck



b. Superstructure



c. Substructure

Figure 75. Condition Rating error distribution by element type and General Condition.

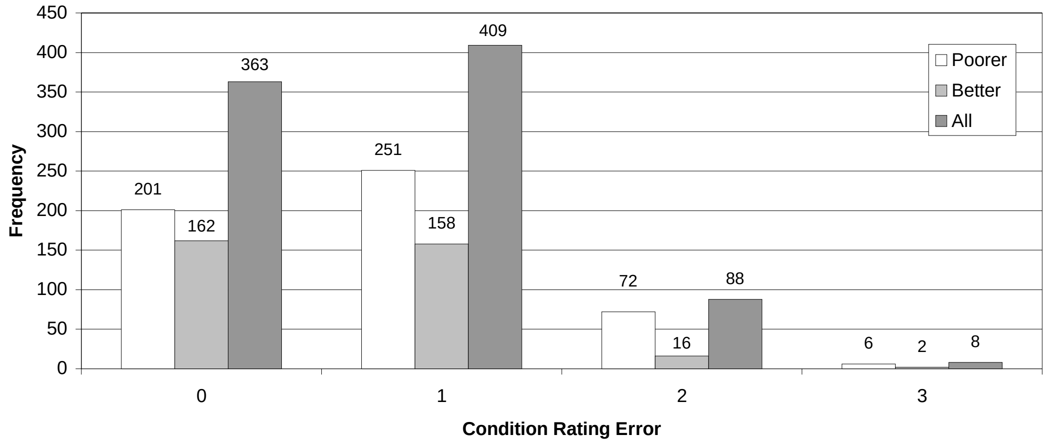


Figure 76. Condition Rating error distribution for all elements by element General Condition.

5.2.3.1.6.   Consistency of Inspection Ratings by Element Type and Element Condition

A useful piece of information for bridge owners is the level of inspector consistency between different elements of a bridge (i.e., does an inspector who tends to rate decks low also do so for superstructures and substructures?). Table 85 summarizes this relationship. The procedure for developing the data in table 85 was to first calculate each inspector's average DFR by element type. This resulted in three average DFRs for each inspector (i.e., one for the decks, one for the superstructures, and one for the substructures). For each element type combination (e.g., deck and superstructure, superstructure and substructure, etc.), the number of inspectors in each case was then tallied. As an example, if an inspector's average Deck DFR was 0.5 and the average superstructure DFR was 0.3, the inspector would be tallied under the "Always Positive" case for the "Deck and Superstructure" element combination. The table also indicates, for some cases, the frequency with which both or all average DFRs were within one rating point.

From table 85, it can be seen that inspectors were, in general, consistent for DFR for different element types. Specifically, 83 percent of the deck/superstructure element combination, 84 percent of the superstructure/substructure element combination, and 67 percent of the substructure/deck element combination had average DFRs that were either always positive or always negative. Also in this table is the subcategory data related to the general accuracy. This indicates that most inspectors were, for a given case, within one rating point for both elements.

Table 85. Inspection consistency by element type.

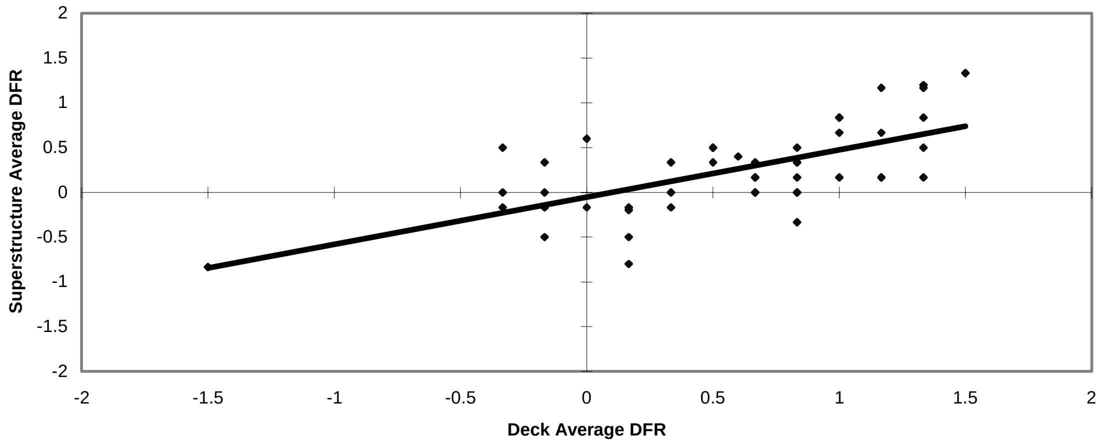
Case	Deck and Superstructure	Superstructure and Substructure	Substructure and Deck	Deck, Superstructure, and Substructure
Always Positive	33 (67%)	23 (47%)	23 (47%)	22 (45%)
within +1	*24 (49%)*	*19 (39%)*	*13 (27%)*	*12 (24%)*
Always Negative	8 (16%)	18 (37%)	10 (20%)	8 (16%)
within -1	*7 (14%)*	*17 (35%)*	*9 (18%)*	*7 (14%)*
One Positive/ One Negative	8 (16%)	8 (16%)	16 (33%)	N/A
within ±1	*8 (16%)*	*8 (16%)*	*16 (33%)*	*N/A*
One Positive/ Two Negative	N/A	N/A	N/A	6 (12%)
One Negative/ Two Positive	N/A	N/A	N/A	13 (27%)

N/A = Not applicable.

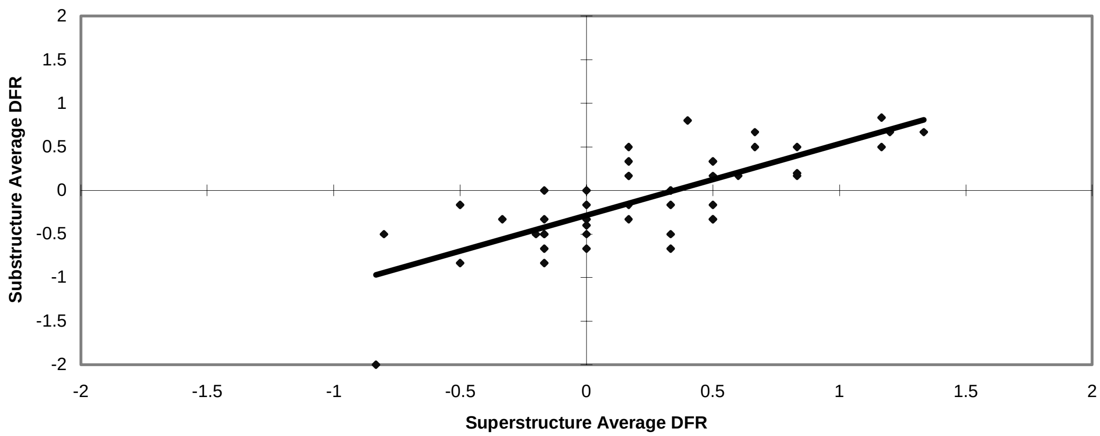
The case where the most inspectors did not fall in the "within one rating point" range was the always positive case.

The relationship between the average element DFR data is also readily apparent from figure 77, which graphically compares the average deviation data for each component against the other components. In addition, a first-order best-fit line has been added to illustrate the general trend for each case. From figure 77 and the data in table 85, it becomes apparent that the relationship between the deviation data is positive in all cases.

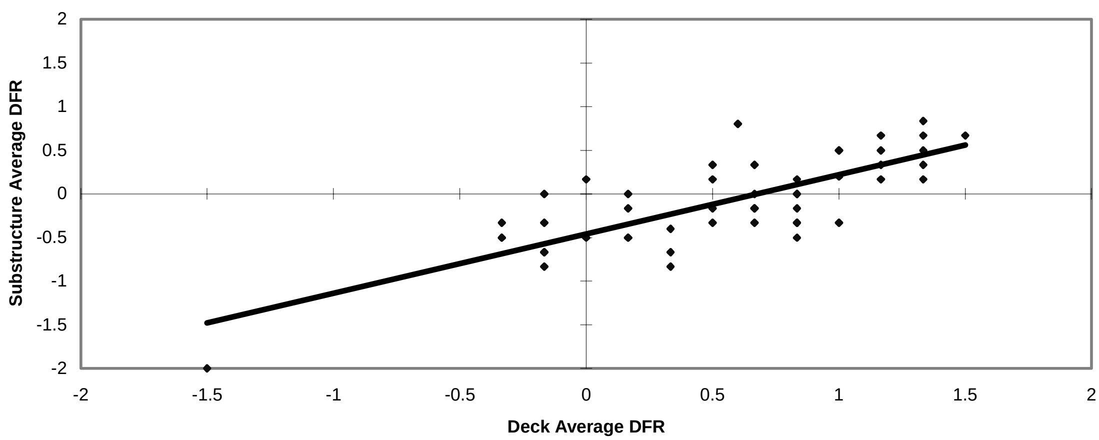
Similar to the previous discussion, table 86 and figure 78 illustrate the relationship between inspections on "poorer" and "better" condition elements. Although the relationship is not as clear from the tabular values, when one combines figure 78 with table 86, it becomes apparent that there is a positive correlation between the average DFR for "better" and "poorer" condition elements. However, the relationship has a negative vertical shift and a smaller slope than those exhibited in figure 77.



a. Deck and Superstructure



b. Superstructure and Substructure



c. Substructure and Deck

Figure 77. Consistency of DFR by element type.

Table 86. Inspection consistency by element General Condition.

Case		“better” and “poorer”
Always Positive		17 (35%)
	within +1	*11 (22%)*
Always Negative		7 (14%)
	within -1	*6 (12%)*
One Positive/One Negative		25 (51%)
	within ±1	*25 (51%)*

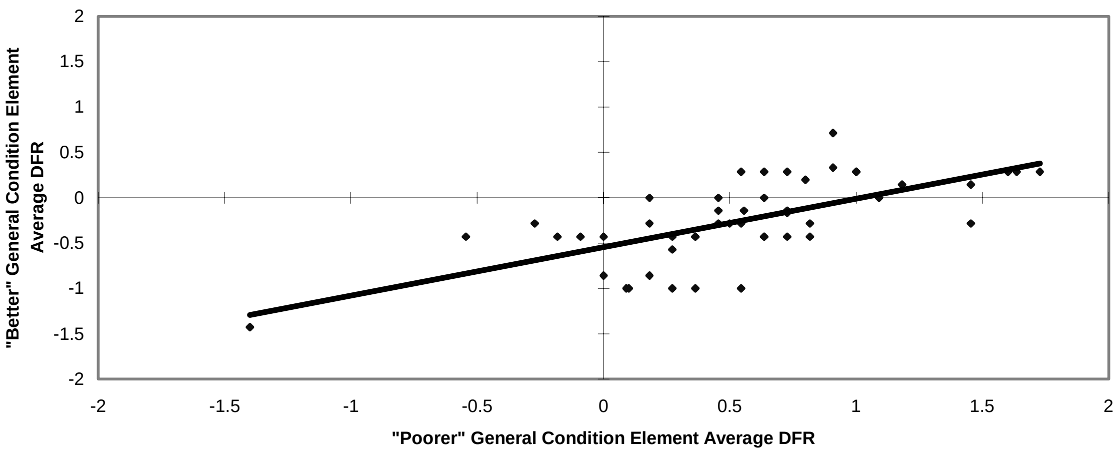


Figure 78. Consistency of DFR by element General Condition.

5.2.3.1.7. Inspector Dispersion and Inspector DFR Range

Table 87 summarizes inspector dispersion of the DFR data. Inspector dispersion is the spread in the DFR data from an individual inspector. These data describe the variability in DFRs for each inspector. Note that an inspector who always had the same DFR would have a dispersion of 0, regardless of the accuracy of the Condition Ratings. Therefore, Inspector dispersion is not a measure of inspector accuracy, but rather an indicator of consistency.

The data in table 87 indicate that the greatest dispersion in inspection results was from assessments of the substructures and from the “poorer” General Condition elements. The minimum and maximum dispersion data indicate the range of inspector dispersions. These

Table 87. Inspector dispersion of DFR.

		Average Inspector Dispersion	Minimum Inspector Dispersion	Maximum Inspector Dispersion
Element Type	Deck	0.75	0.00	1.47
	Superstructure	0.77	0.00	1.33
	Substructure	0.80	0.41	1.47
General Condition	poorer	0.73	0.40	1.38
	better	0.69	0.00	1.27
Overall		0.84	0.50	1.15

ranged from a dispersion of 0.0 (i.e., always having the same DFR value) to a dispersion of approximately 1.5.

In order to extrapolate the experimental data to the population, a normal distribution was applied to these data and was tested for goodness-of-fit. Results from the application of the normal distribution are illustrated in figure 79. The goodness-of-fit test revealed that the normal distribution is an appropriate approximation for the overall dispersion data. From this, it can be concluded that 95 percent of the inspectors will have a DFR dispersion of 0.55 to 1.12.

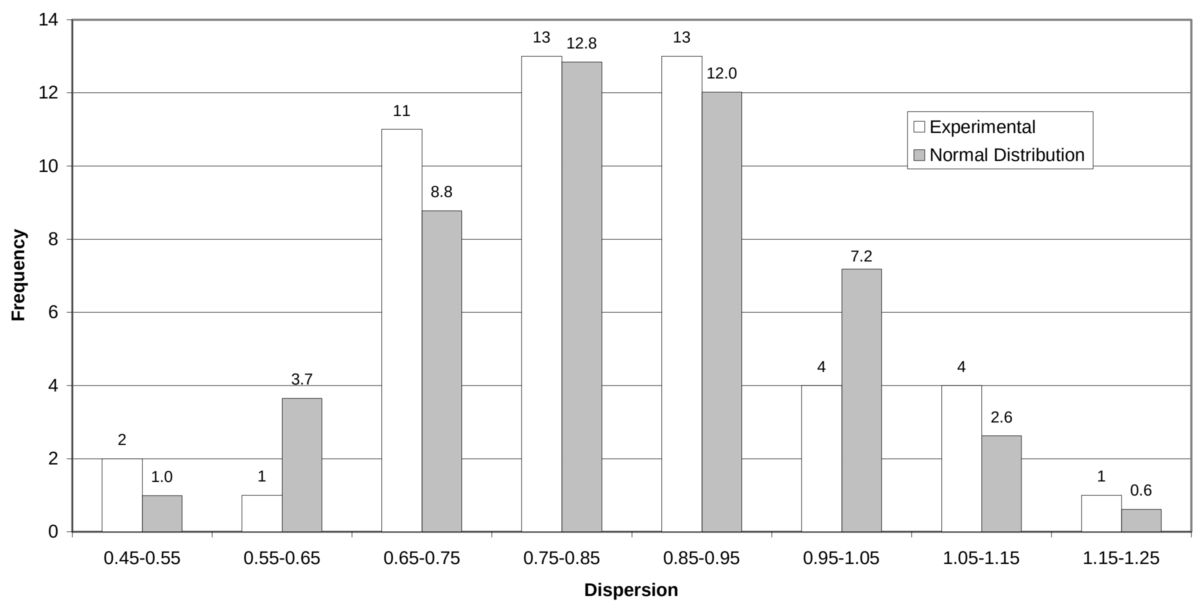


Figure 79. Experimental and normal distributions of inspector dispersion.

Table 88 summarizes the range of DFRs for the sample of inspectors. This table shows the average DFR range, the dispersion of these ranges, and the minimum and maximum DFR ranges for each category. The data indicate that the substructures and the “poorer” condition elements had the largest average range of DFR data, which reiterates many of the previously given findings. In addition, it can be observed that, on average, inspectors had a DFR range of 2.94. This indicates that the average inspector gave Condition Ratings that ranged in DFR by approximately three points (e.g., -3 to 0, -1 to +2, 0 to +3, etc.), with a lowest DFR range of 1 and a highest range of 4. From the table, it can be seen that the average range for each element (i.e., deck, superstructure, or substructure) is less than the overall by approximately one point. This indicates that there is greater consistency for a single element type than for all element types combined.

Table 88. Range of DFRs.

		Average Range	Range Standard Deviation	Minimum Range	Maximum Range
Element Type					
	Deck	1.88	0.83	0	4
	Superstructure	1.88	0.81	0	3
	Substructure	1.96	0.79	1	4
General Condition					
	poorer	2.16	0.72	0	4
	better	1.73	0.70	0	3
Overall		2.94	0.69	1	4

5.2.3.1.8. Variability in Condition Ratings by State

Although the sample of inspectors were instructed to use the same Condition Rating system, it was thought that differences in interpretation of the Condition Rating definitions may exist between States. The following will present results related to differences in Condition Rating assignment by individual States. Note that for much of this discussion, reference will be made to various States. This should not imply that the two inspectors from each State worked together, but rather were from the same State. Furthermore, it must be pointed out that the sample size from any State is only two and it may not be statistically correct to extrapolate these results to each State's entire population of bridge inspectors

Table 89 summarizes how consistent inspectors from the same State were with respect to their Condition Rating assignment. The data in Table 89 are the difference between the Condition Ratings assigned by the inspectors from each individual State for each task. From these data, it can be seen that in approximately 90 percent of the cases, the two inspectors from the same State were within one rating point of each other.

Table 90 gives the probability that the average Condition Ratings assigned by the inspectors from each State for each task are not statistically different from the remainder of the sample. Tables 91 and 92 give the average probability for each State by element type and element condition. From the data in these tables, it can be seen that the average Condition Ratings from most States are not statistically different from the sample. The one exception to this is State 6. The difference is most prominent in assigning Condition Ratings to poorer condition elements, but can also be seen in the other groupings of elements.

Tables 93 through 95 summarize the influence of the use of various State QA/QC procedures on Condition Rating assignment. To accomplish these analyses, the inspectors were grouped by the type of QA/QC programs that their respective States had identified in the survey of States presented previously. As can be seen from these data, the only QA/QC procedure that may have influenced Condition Rating assignment in this study is the rotation of inspectors to different bridges.

5.2.3.2. REGRESSION ANALYSIS OF MEASURED FACTORS WITH SAMPLE ROUTINE INSPECTION RESULTS

The following presents regression analysis results using the previously presented data (i.e., Condition Ratings and measured factors). The goal of this analysis was to determine if, and to what extent, the human and environmental factors correlated with the Routine Inspection results. This discussion will focus exclusively on examining the relationship between the human and

Table 89. Difference in assigned Condition Rating by State.

State	Task A			Task B			Task C		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
1	0	0	1	0	0	0	0	1	1
2	0	0	1	1	0	0	0	1	1
3	1	3	1	1	1	1	0	2	1
4	1	1	0	0	0	2	1	0	1
5	1	1	2	0	0	0	2	1	0
6	3	0	2	2	1	0	1	1	N/A
7	1	0	1	1	1	0	1	0	0
8	1	2	1	0	0	0	1	2	1
9	1	1	0	2	1	1	0	0	1
10	0	0	1	0	1	0	1	1	1
11	1	1	1	1	0	1	0	0	1
12	0	0	0	N/A*	2	1	1	1	0
13	1	0	2	1	2	1	0	2	1
14	1	1	0	1	0	1	1	1	1
15	0	1	1	1	1	0	1	1	1
16	1	0	0	1	1	1	1	1	1
17	0	1	1	1	0	0	1	1	1
18	0	1	0	0	1	1	1	0	1
19	1	0	0	1	1	2	2	1	2
20	2	2	0	2	1	2	2	2	2
21	0	0	0	1	0	1	1	0	0
22	0	0	1	2	0	2	2	1	1
23	0	0	1	0	0	1	0	1	0
24	0	0	0	0	0	0	1	0	2

Table 89. Difference in assigned Condition Rating by State (continued).

State	Task D			Task E			Task G		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
1	1	1	0	0	0	N/A	0	1	0
2	0	0	0	0	0	1	1	0	1
3	1	2	1	1	1	1	0	0	0
4	0	0	1	1	1	0	1	1	0
5	0	0	0	0	1	1	1	1	1
6	1	1	2	1	2	1	0	1	1
7	2	2	0	2	2	0	1	0	0
8	1	N/A	1	0	1	1	1	0	0
9	1	2	1	0	2	2	0	1	0
10	0	0	0	1	0	0	1	0	0
11	N/A	2	0	0	0	0	0	0	1
12	2	N/A	1	0	0	0	0	0	0
13	1	2	0	0	1	0	0	0	1
14	1	1	1	1	1	1	0	0	0
15	0	N/A	2	0	1	1	2	2	0
16	1	1	1	1	0	0	0	0	0
17	0	1	N/A	0	1	0	1	1	0
18	1	1	0	0	1	1	0	1	0
19	1	0	N/A	2	2	0	1	1	0
20	2	2	2	2	1	2	0	0	0
21	0	0	1	0	0	1	0	0	0
22	0	0	0	N/A	N/A	N/A	0	0	1
23	1	2	1	1	0	0	0	2	0
24	1	1	0	0	0	1	1	1	1

*N/A = Not available.

Table 90. Probability of difference in Condition Rating by State.

State	Task A			Task B			Task C		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
1	15%	11%	24%	85%	68%	18%	80%	85%	100%
2	75%	1%	52%	34%	68%	59%	19%	85%	100%
3	23%	49%	52%	34%	61%	69%	19%	52%	100%
4	58%	N/A*	80%	18%	61%	59%	30%	52%	100%
5	58%	25%	80%	18%	61%	59%	80%	85%	35%
6	2%	11%	0.002%	0.003%	0.07%	1%	1%	0.02%	N/A
7	58%	82%	24%	58%	18%	59%	60%	31%	35%
8	23%	82%	52%	85%	15%	18%	60%	2%	6%
9	23%	25%	12%	8%	61%	69%	19%	52%	6%
10	75%	82%	52%	85%	2%	59%	30%	14%	6%
11	23%	25%	52%	34%	15%	2%	19%	52%	6%
12	75%	82%	80%	N/A	68%	69%	60%	85%	35%
13	23%	11%	80%	34%	15%	69%	19%	52%	100%
14	58%	49%	80%	57%	68%	69%	30%	85%	100%
15	75%	49%	52%	57%	18%	59%	60%	85%	100%
16	23%	82%	80%	57%	61%	14%	30%	85%	100%
17	75%	25%	52%	34%	68%	59%	60%	85%	100%
18	75%	49%	80%	18%	61%	69%	30%	52%	100%
19	58%	82%	80%	57%	61%	59%	80%	85%	35%
20	15%	4%	12%	8%	61%	18%	80%	52%	35%
21	15%	25%	80%	34%	68%	14%	80%	52%	35%
22	3%	82%	52%	85%	68%	18%	80%	85%	100%
23	15%	49%	24%	18%	68%	69%	7%	85%	35%
24	75%	82%	12%	8%	68%	59%	3%	31%	35%

Table 90. Probability of difference in Condition Rating by State (continued).

State	Task D			Task E			Task G		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
1	29%	74%	87%	30%	12%	N/A	0.3%	1%	0.2%
2	78%	63%	15%	38%	65%	70%	26%	46%	42%
3	64%	25%	53%	6%	59%	70%	83%	46%	64%
4	21%	63%	33%	4%	N/A	63%	12%	1%	64%
5	21%	3%	7%	30%	1%	18%	12%	74%	8%
6	0.02%	19%	7%	4%	65%	0.1%	83%	74%	42%
7	78%	63%	87%	38%	65%	63%	26%	46%	4%
8	29%	N/A	53%	38%	59%	70%	26%	46%	64%
9	64%	63%	2%	38%	65%	21%	83%	74%	4%
10	7%	25%	15%	94%	65%	21%	26%	16%	64%
11	N/A	25%	15%	38%	1%	0.2%	83%	46%	8%
12	21%	N/A	53%	30%	65%	63%	83%	46%	64%
13	29%	25%	87%	38%	59%	63%	83%	46%	42%
14	64%	19%	33%	94%	59%	70%	83%	46%	4%
15	21%	N/A	87%	30%	59%	70%	83%	16%	64%
16	29%	74%	33%	94%	65%	63%	83%	46%	64%
17	78%	74%	N/A	38%	59%	63%	26%	74%	64%
18	64%	19%	87%	38%	59%	70%	83%	74%	64%
19	64%	63%	N/A	30%	65%	63%	26%	6%	4%
20	79%	63%	87%	38%	15%	63%	83%	46%	64%
21	79%	63%	33%	38%	65%	71%	83%	46%	64%
22	7%	25%	15%	N/A	N/A	N/A	83%	46%	42%
23	64%	25%	1%	4%	65%	63%	83%	16%	64%
24	29%	74%	1%	38%	65%	70%	26%	74%	42%

*N/A = Not available.

Table 91. Average probability of difference in Condition Rating by State and element type.

Team	Deck	Superstructure	Substructure	All Elements
1	40%	42%	46%	42%
2	45%	56%	56%	53%
3	38%	49%	68%	52%
4	24%	44%	67%	45%
5	27%	42%	35%	38%
6	15%	28%	10%	18%
7	53%	51%	45%	50%
8	44%	41%	44%	43%
9	39%	57%	19%	38%
10	53%	34%	36%	41%
11	39%	27%	14%	26%
12	54%	69%	61%	61%
13	38%	35%	74%	49%
14	64%	54%	59%	59%
15	54%	45%	72%	58%
16	53%	69%	59%	60%
17	52%	64%	68%	61%
18	51%	52%	78%	61%
19	53%	60%	48%	54%
20	50%	40%	47%	46%
21	55%	53%	50%	52%
22	52%	61%	45%	63%
23	32%	51%	43%	42%
24	30%	66%	37%	44%

environmental factors and the primary element Condition Ratings (i.e., deck, superstructure, and substructure).

For the following discussion, the human and environmental factors have been regrouped to facilitate completing the analysis. The factors will be divided into two categories – inspector and inspection factors. The inspector factors are those factors that were measured from the SRQ and vision testing. The inspection factors are those factors that were measured during a specific inspection through the pre-task evaluations, firsthand observations, or the post-task evaluations (e.g., Temperature, Inspector Rested Level, etc.).

This categorization resulted in 26 discrete inspector factors used in these analyses. The following list summarizes the inspector factors and the source of the inspector factor

Table 92. Average probability of difference in Condition Rating by State and element condition.

Team	Poorer	Better	All Elements
1	54%	21%	42%
2	57%	46%	53%
3	46%	51%	52%
4	47%	42%	45%
5	43%	29%	38%
6	4%	39%	18%
7	53%	45%	50%
8	36%	53%	43%
9	39%	37%	38%
10	44%	37%	41%
11	24%	29%	26%
12	58%	65%	61%
13	37%	66%	49%
14	63%	54%	59%
15	55%	62%	58%
16	59%	62%	60%
17	63%	56%	61%
18	52%	74%	61%
19	61%	41%	54%
20	41%	53%	46%
21	46%	63%	52%
22	55%	48%	63%
23	40%	45%	42%
24	46%	41%	44%

measurement:

- Age (SRQ1)
- Height (SRQ1)
- Weight (SRQ1)
- General Physical Condition (SRQ2)
- General Mental Condition (SRQ5)
- Perception of Bridge Inspection Importance to Public Safety (SRQ9)
- Public Safety Assessment During Bridge Inspection (SRQ10)
- General Mental Focus (SRQ11)
- Reported Fear of Heights (SRQ13)
- Reported Fear of Enclosed Spaces (SRQ14)

Table 93. Probability of difference of Condition Rating assignment by QA/QC program.

QA/QC Type	Task A			Task B			Task C		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
Any	96%	41%	67%	85%	94%	73%	68%	57%	76%
Report Review	52%	32%	95%	83%	20%	25%	70%	45%	84%
Field Review	79%	95%	24%	11%	95%	4%	25%	31%	71%
Independent Reinspection	2%	21%	28%	93%	57%	70%	81%	81%	65%
FHWA Review	72%	32%	25%	22%	91%	39%	9%	65%	36%
Training/ Meetings	43%	21%	13%	7%	57%	19%	7%	20%	48%
Rotation of Inspectors	3%	32%	0.2%	1%	5%	3%	4%	1%	5%

Table 93. Probability of difference of Condition Rating assignment by QA/QC program (continued).

QA/QC Type	Task D			Task E			Task G		
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure
Any	64%	92%	42%	86%	23%	43%	61%	22%	8%
Report Review	40%	84%	89%	99%	65%	88%	57%	81%	36%
Field Review	92%	46%	16%	58%	14%	2%	26%	66%	37%
Independent Reinspection	74%	99%	22%	25%	89%	83%	59%	78%	61%
FHWA Review	96%	70%	21%	45%	89%	92%	44%	18%	5%
Training/ Meetings	24%	67%	41%	36%	97%	27%	23%	78%	92%
Rotation of Inspectors	0.3%	20%	7%	2%	51%	1%	52%	28%	11%

Table 94. Average probability of difference in Condition Rating by QA/QC type and element type.

QA/QC Type	Deck	Superstructure	Substructure	All Elements
Any	77%	55%	52%	61%
Report Review	67%	55%	70%	64%
Field Review	49%	58%	26%	44%
Independent Reinspection	56%	71%	55%	60%
FHWA Review	48%	61%	36%	48%
Training/Meeting	23%	57%	40%	40%
Rotation of Inspectors	10%	23%	5%	13%

Table 95. Average probability of difference in Condition Rating by QA/QC type and element condition.

QA/QC Type	Poorer	Better	All Elements
Any	76%	38%	61%
Report Review	58%	73%	64%
Field Review	55%	26%	44%
Independent Reinspection	61%	60%	60%
FHWA Review	53%	42%	48%
Training/Meeting	32%	53%	40%
Rotation of Inspectors	7%	22%	13%

- Reported Fear of Traffic (SRQ15)
- Experience in Bridge Inspection (SRQ20)
- Experience in Highway Structures (SRQ21)
- Estimated Additional Years as a Bridge Inspector (SRQ23)
- Quality of Relationship With Supervisor (SRQ27)
- Perceived Importance of Work by Management (SRQ28)
- Percentage of Time on Bridge Inspection (SRQ29)
- Percentage of Routine Inspections (SRQ30)
- Comparison to Other Inspectors (SRQ34)
- Number of Annual Bridge Inspections (SRQ38)
- General Education Level (SRQ18)
- Formal Bridge Inspection Training (SRQ19)
- Jet Lag (SRQ37)
- Color Vision (two different measures from PV-16 color vision test)

- Near Visual Acuity (right and left eye from near vision test)
- Distance Visual Acuity (right and left eye from distance vision test)

Twenty-one discrete inspection factors were also identified. The following list summarizes these factors and the source of their measurement:

- Time Since Similar Inspection (pre-task questionnaire)
- Estimated Time for Task (pre-task questionnaire)
- Rested Level Before Task (pre-task questionnaire)
- Wind Speed (direct environmental measurement)
- Light Intensity Below Superstructure (direct environmental measurement)
- Light Intensity on Deck (direct environmental measurement)
- Heat Index (direct environmental measurement)
- Observed Inspector Focus Level (firsthand observation)
- Observed Inspector Rushed Level (firsthand observation)
- Actual Time to Complete Task (firsthand observation)
- Reported Task Similarity to Normal (post-task questionnaire)
- Accuracy of Task at Measuring Inspection Skills (post-task questionnaire)
- Rested Level After Task (post-task questionnaire)
- Reported Level of Instruction Understanding (post-task questionnaire)
- Reported Structure Accessibility Level (post-task questionnaire)
- Reported Structure Maintenance Level (post-task questionnaire)
- Reported Structure Complexity Level (post-task questionnaire)
- Reported Observer Influence (post-task questionnaire)
- Reported Rushed Level (post-task questionnaire)
- Reported Effort Level (post-task questionnaire)
- Reported Thoroughness Level (post-task questionnaire)

Most of the inspector and inspection factors used in the analyses presented in this section were assessed in such a way that quantitative data could be collected. However, some of the data were collected in a purely qualitative form. The qualitative data were subsequently transformed into a pseudo-quantitative form for use in the regression analyses. Specifically, the inspector factor "General Education Level" was transformed into a quantitative form using the following scale:

1 = Some high school
2 = High school degree or equivalent
3 = Some trade school
4 = Trade school degree
5 = Some college
6 = Associate's degree
7 = Bachelor's degree
8 = Some graduate work
9 = Master's degree
10 = Terminal degree

Similarly, the "Formal Bridge Inspection Training" factor was calculated as the total number of FHWA training courses that an inspector had reported completing.

Color vision attributes were quantified in two different manners to simulate different uses of color vision. First, the total number of minor confusions (i.e., errors between contiguous test caps) from the PV-16 color vision test was used as a measure of inspector ability to distinguish similar colors. It was speculated that this could be of importance in assessing structural deterioration that manifests itself only as a slight change in color (e.g., some types of concrete deterioration). Second, the number of major confusions from the PV-16 color vision test was used as a measure of inspector ability to distinguish specific colors (e.g., red). It was thought that this type of color vision may be a trait necessary for fatigue crack detection. Direct visual acuity (both near and distance) was quantified as the "bottom" number from the vision test results (e.g., 20/12.5 equals a visual acuity of 12.5).

Two major categories of results will be presented. First, the discussion focuses on factor correlation with respect to specific tasks and element types. Second, the correlation of the factors with the DFR is presented. Recall that the DFR is calculated as the inspector's Condition Rating minus the corresponding reference rating.

Before presenting the results of the regression analyses, the limitations associated with this type of analysis must be discussed. There are four primary general limitations on any regression analysis and each will be discussed in the following paragraphs.

The first limitation has to do with extrapolation of the factors to levels not measured in this study. In essence, this limitation requires that all factors input into the developed equations be within the range of those measured in the study. For example, equations with terms based on the "General Mental Condition" factor are only valid over a range from 3 to 5.

The second limitation relates to the generalization of the regression results from the sample to the population of bridge inspectors. The danger in making generalizations to the population is that the two groups (i.e., the sample and the population) might not posses identical characteristics. As such, generalizations may not be statistically valid.

Making assertions of causation is the third point of limitation. Cause-and-effect relationships between the independent and dependent factors cannot be established solely on the basis of a regression analysis. To be able to make statements about causation, it is not only required to show accurate prediction in the response to the independent variables, but also that the independent variables control the response. In other words, causation demands that changes in the dependent variables can be induced by changes in the identified independent variables and that the identified independent variables are the only variables that influence the magnitude of the response. Establishing causation is beyond the scope of this study.

The final limitation lies in the method of measuring the variables. Statements indicating that a factor or a set of factors have a high correlation coefficient with the dependent data may only be valid for the specific techniques used in this study to measure them. In other words, any resulting equations that contain the factor "Reported Fear of Traffic" are only valid when measuring the "Reported Fear of Traffic" with question SRQ15.

Although these limitations must be recognized, they do not imply that the regression analysis results are without value. Accepting these limitations, the value lies in the fact that the regression analysis results can be used to accurately predict the sample results under the experimental conditions. If one can also accept that the sample and the population possess similar characteristics, then the regression results can be used to predict hypothetical inspection results. The level of required similarity depends solely on the level of risk one is willing to accept.

5.2.3.2.1. Condition Ratings

The following summarizes the regression analysis of the Condition Ratings for Tasks A through E, and Task G. The regression analysis results for predicting inspector Condition Ratings will be presented in three sections. The first presents the developed regression equation solely in terms of the inspector factors. Second, the regression analysis results solely in terms of the inspection factors alone are presented. Finally, the inspector and inspection factors are analyzed simultaneously to predict the Condition Ratings. By first considering the inspector and inspection factors individually and then examining them together, one can develop a greater understanding of the correlation of each, in addition to their interdependence.

INSPECTOR FACTORS: The procedure for establishing the regression equation for predicting the Condition Ratings in terms of the inspector factors was completed as follows. The first step was to establish whether the Condition Ratings varied linearly with any single factor. Although there were some factors that did have high (i.e., greater than 0.5) linear correlation coefficients with an individual element on a single task, none showed a consistently high degree of correlation with multiple tasks or elements. The second step was to establish whether the Condition Ratings varied with a second-order variation in the individual factors. As before, no consistent correlation existed. At this point, other types of simple functions were investigated (e.g., logarithmic, exponential, etc.) for correlation. Again, no significant relationship existed.

Since no single factor could be found to correlate with the Condition Ratings, a multivariate equation was needed. Again, starting with only linear variations in the factors, different combinations were investigated. As before, no significant relationship could be established using linear combinations alone. The final step was to use a second-order, multivariate equation.

In order to ensure that the equations were useful, it was desirable to keep the number of variables to a minimum. In addition, since the inspector factors were constant for all tasks, it was desirable to find a single set of inspector factors that could be used for all tasks. Initially, only a few factors were combined together, with the selection of factors based on the individual level of correlation with the Condition Ratings. In other words, those factors with the highest individual second order correlation coefficients were the first to be analyzed together. It quickly became apparent that seven factors would be needed to consistently obtain significant correlation coefficients. However, it should be pointed out that this does not mean that individual Condition Ratings could not be satisfactorily predicted using fewer factors, rather, for the combination of six tasks together, a non-linear equation in terms of seven variables is required.

After the initial selection of the seven factors, various other combinations of factors were evaluated to ensure that the initial selection had a significant degree of correlation. In no case could a correlation coefficient higher than that identified previously be found.

Using the above outlined procedure, Equation 2 was developed to predict the Condition Ratings in terms of seven non-linear inspector factors.

$$\text{Condition Rating} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \tag{2}$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Fear of Traffic

F_2 = General Mental Condition

F_3 = Number of Annual Bridge Inspections

F_4 = General Education Level

F_5 = Right Eye Near Visual Acuity

F_6 = Color Vision (minor confusions)

F_7 = Formal Bridge Inspection Training

Values for the coefficients y_0 and a through n for the deck Condition Rating equation are given in table 96. Similarly, the coefficients for the superstructure and substructure equations are given in tables 97 and 98, respectively. The correlation coefficients obtained for each of these equations are given in table 99, illustrating the accuracy of these equations at predicting the sample Condition Ratings. The fact that the identified inspector factors resulted in high correlation coefficients can easily be rationalized because the possible existence of a relationship between the Condition Ratings and the factor is highly intuitive. Clearly, how distracted the inspector is by the traffic (i.e., Reported Fear of Traffic) could influence the condition assessments. In addition, the inspector's General Mental Condition, General Education Level, and Formal Bridge Inspection Training all relate to the inspector's mental condition and

Table 96. Equation coefficients for predicting deck Condition Ratings – Inspector factors.

Coefficient	Task					
	A	B	C	D	E	G
y_0	2.59	-6.64	0.97	-8.83	7.12	9.67
a	1.54	0.610	-0.103	2.43	-1.62	0.417
b	-0.214	-.0154	0.104	-0.410	0.412	-0.0911
c	1.60	5.98	1.71	5.45	-0.868	-1.51
d	-0.269	-0.910	-0.275	-0.766	0.0826	0.216
e	-2.94e-4	4.37e-3	0.0052	6.28e-4	3.06e-3	3.94e-4
f	-6.26e-7	-4.33e-6	-5.51e-6	-1.76e-7	-4.32e-6	-9.19e-7
g	-0.478	0.0843	0.155	0.189	0.594	0.0520
h	0.0580	0.055	-0.0061	-0.0122	-0.0729	-5.96e-4
i	-.0445	-0.0270	-0.0102	-0.0122	-0.0280	-.0380
j	2.82e-4	1.98e-4	8.79e-5	1.15e-4	1.55e-4	2.06e-4
k	-0.161	-0.170	-0.224	0.0615	-0.2145	-0.160
l	0.0352	0.0160	0.0381	3.28e-3	0.0251	0.0168
m	0.123	-0.167	-0.378	0.114	-0.0138	-0.0315
n	-.0100	0.0245	0.0099	-0.156	0.0190	0.0146

Table 97. Equation coefficients for predicting superstructure Condition Ratings – Inspector factors.

Coefficient	Task					
	A	B	C	D	E	G
y_0	8.32	0.583	3.42	-7.13	5.31	11.57
a	0.461	2.24	0.885	-3.80	0.0420	-0.601
b	-0.0258	-0.390	-0.0690	0.776	0.0616	0.114
c	-1.49	0.994	0.414	7.86	-0.790	-2.48
d	0.207	-0.160	-0.116	-1.047	0.0908	0.320
e	-9.66e-4	-2.15e-3	-6.66e-4	0.0053	-6.12e-4	2.85e-3
f	3.66e-7	1.38e-6	5.35e-7	-3.35e-6	-6.96e-7	-3.10e-6
g	-0.245	-0.346	-0.226	-0.0938	1.38	0.0309
h	0.0234	0.0345	0.032	0.0192	-0.156	-1.28e-3
i	-0.0216	-1.68e-3	-4.44e-3	-0.0322	-0.0341	-0.0163
j	1.46e-4	2.37e-5	2.70e-5	2.83e-4	2.36e-4	1.06e-4
k	0.0495	-0.185	-0.255	0.269	-0.0126	-0.0128
l	-0.0155	0.0464	0.0487	-0.0256	-0.0121	0.0069
m	0.306	0.146	0.0073	0.187	0.0561	0.0516
n	-0.0435	-1.47e-3	0.0192	-0.0035	8.80e-4	4.25e-5

Table 98. Equation coefficients for predicting substructure Condition Ratings – Inspector factors.

Coefficient	Task					
	A	B	C	D	E	G
y_0	-4.01	8.24	-5.26	-13.70	4.17	7.56
a	2.41	-0.0358	3.992	0.648	2.15	-0.739
b	-0.40	0.0054	-0.716	-0.125	-0.296	0.160
c	4.13	-0.782	3.70	12.09	-1.014	0.351
d	-0.560	0.0753	-0.511	-1.71	0.134	-0.0757
e	1.38e-3	-9.34e-5	-9.89e-4	-0.00540	7.62e-4	9.37e-4
f	-2.24e-6	2.74e-7	3.62e-7	4.41e-6	-2.98e-6	-1.23e-6
g	-0.47	-0.989	-0.442	0.0755	0.907	0.353
h	0.0567	0.0991	0.0447	0.0132	-0.110	-0.0344
i	-0.0148	-0.0205	-0.0404	-0.0564	-0.110	-0.0259
j	9.11e-5	1.65e-4	2.55e-4	3.84e-4	6.45e-4	1.03e-4
k	-0.0976	-0.177	-0.160	-0.202	-0.382	-0.0346
l	0.180	0.0350	0.0301	0.0434	0.0368	3.68e-3
m	0.180	0.321	0.474	-0.486	0.211	-0.138
n	0.0300	-0.0547	-0.0518	0.0620	-0.0076	0.0199

Table 99. Correlation coefficients for influence of inspector factors on Condition Ratings.

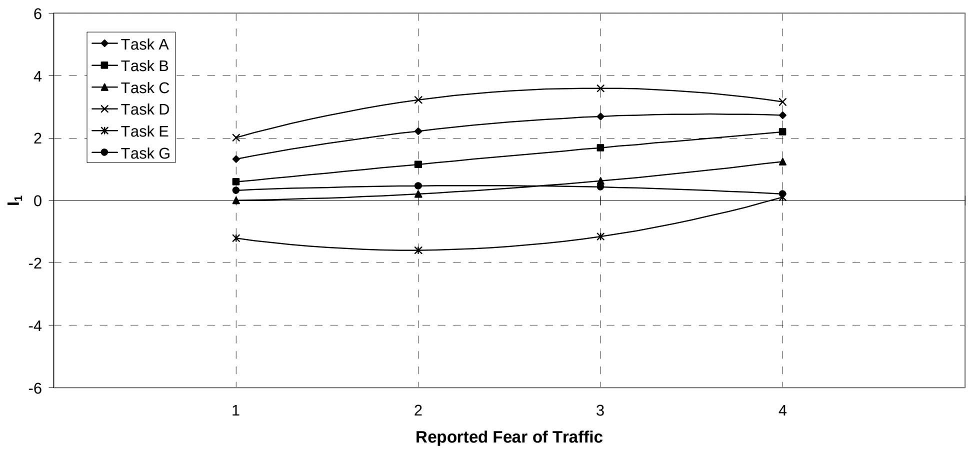
	Task					
Element	A	B	C	D	E	G
Deck	0.75	0.72	0.62	0.62	0.72	0.52
Superstructure	0.49	0.73	0.69	0.50	0.69	0.41
Substructure	0.69	0.67	0.70	0.65	0.84	0.57

capacity, which could influence inspection results. Furthermore, the number of Annual Bridge Inspections can easily be rationalized because it is an indicator of an inspector's overall familiarity with the bridge inspection process. In addition, since the execution of a bridge inspection relies so heavily on an inspector's vision characteristics, it is not surprising that the vision test results did show some correlation.

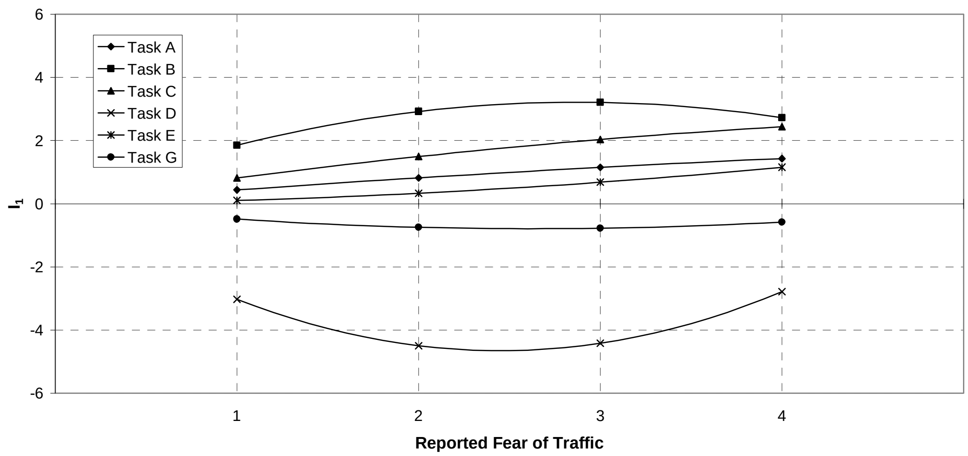
In this section, I_1 through I_7 from Equation 2 are shown graphically in figures 80 through 86, respectively, to illustrate the influence of each of the factors. In subsequent sections, figures presenting factor influence are presented in Appendix L in Volume II. The important information to note in figures 80 through 86 and in similar figures are the general shape and trends. Also note that the magnitude of the curves is of lesser importance, with the range over which a particular curve lies being of greater importance. The reason for these facts result from the form of the general equation.

In general, figures 80 through 86 show relatively consistent trends across the element types and tasks. However, some variability in the relationships can be observed and, generally, should be expected. It is interesting to note that Tasks D, E, and G are typically the tasks where the greatest variations occurred. This can probably be attributed to the relatively complex superstructures (Tasks E and G) or to the relatively uncommon structure type in Task D.

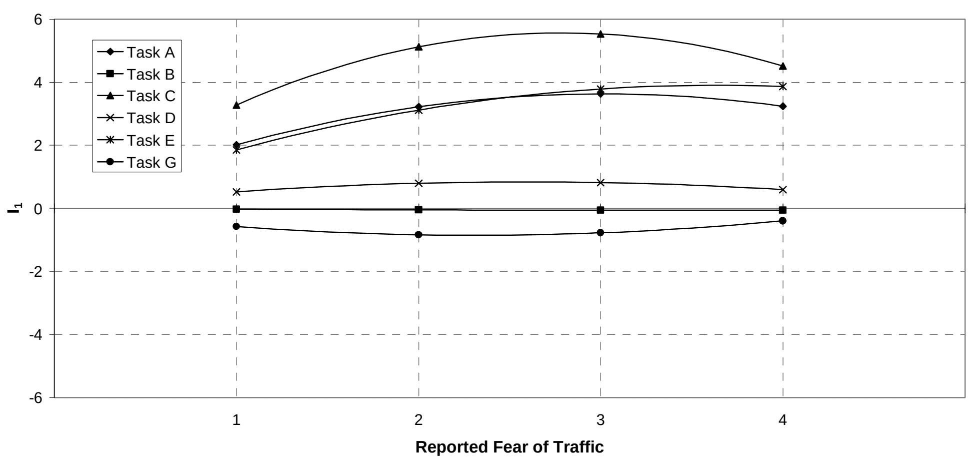
Specifically, the equations that are shown graphically in these figures do not have a constant term. Rather, the constant term y_0 given in the general equation combines the constants for all of the factors into one. In other words, if one could include a constant term in each equation, each line would have been shifted by that amount.



a. Deck

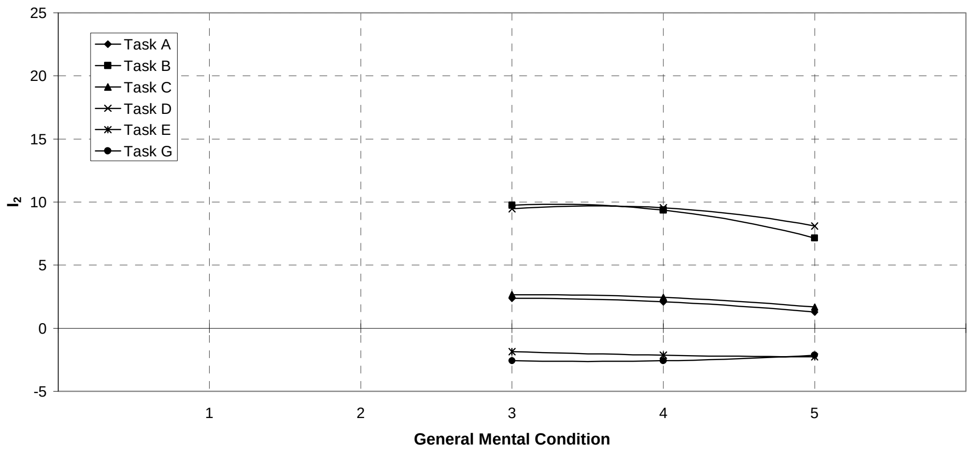


b. Superstructure

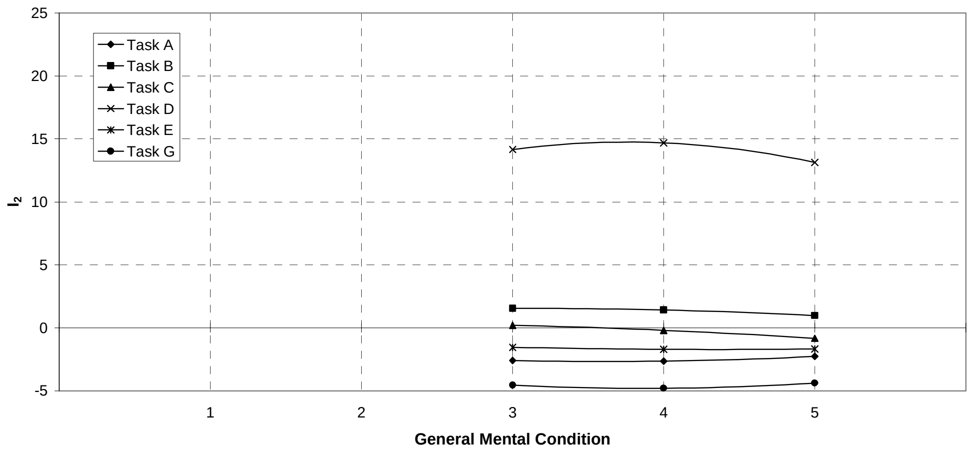


c. Substructure

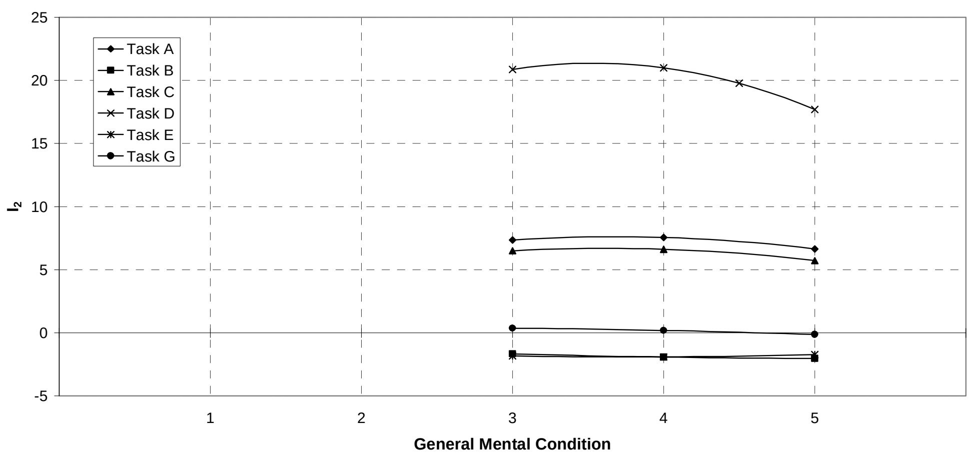
Figure 80. Influence of inspector factor Reported Fear of Traffic (1=Very Fearful, 4=No Fear) on Condition Ratings.



a. Deck

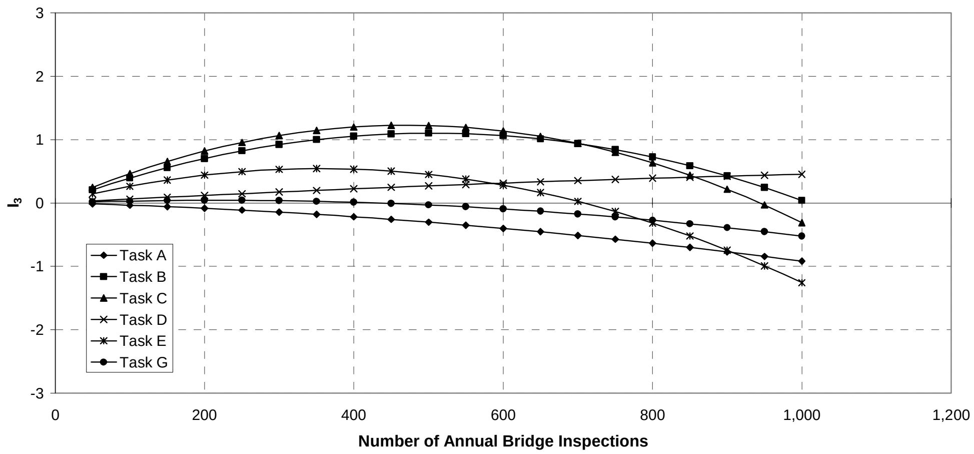


b. Superstructure

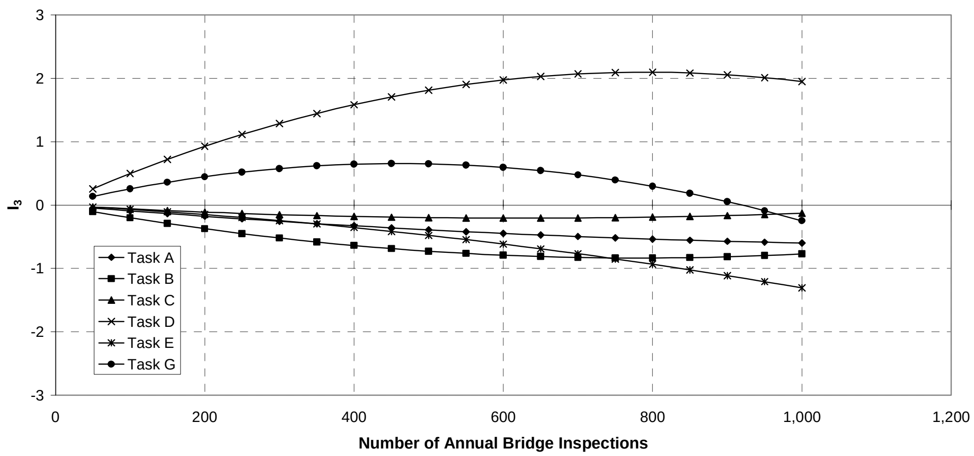


c. Substructure

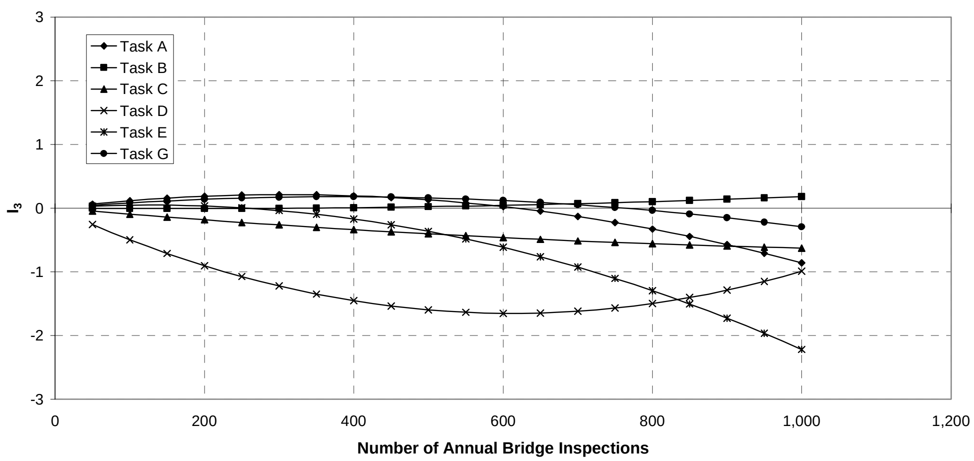
Figure 81. Influence of inspector factor General Mental Condition (1=Poor, 5=Superior) on Condition Ratings.



a. Deck

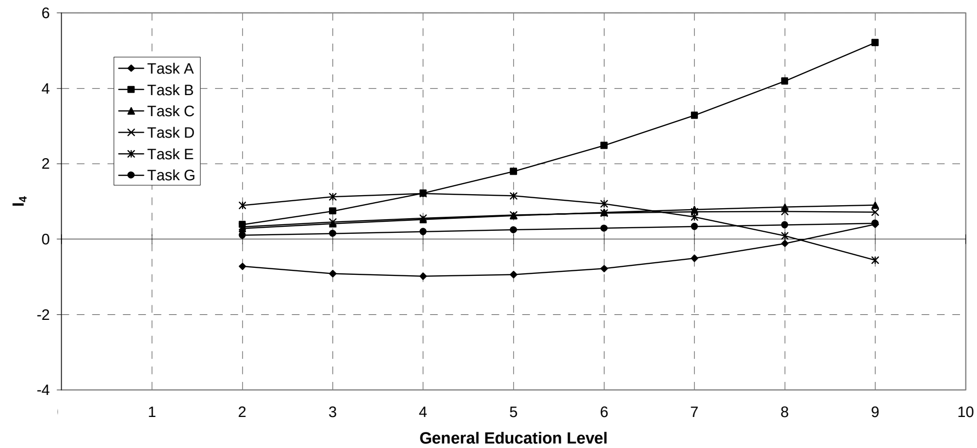


b. Superstructure

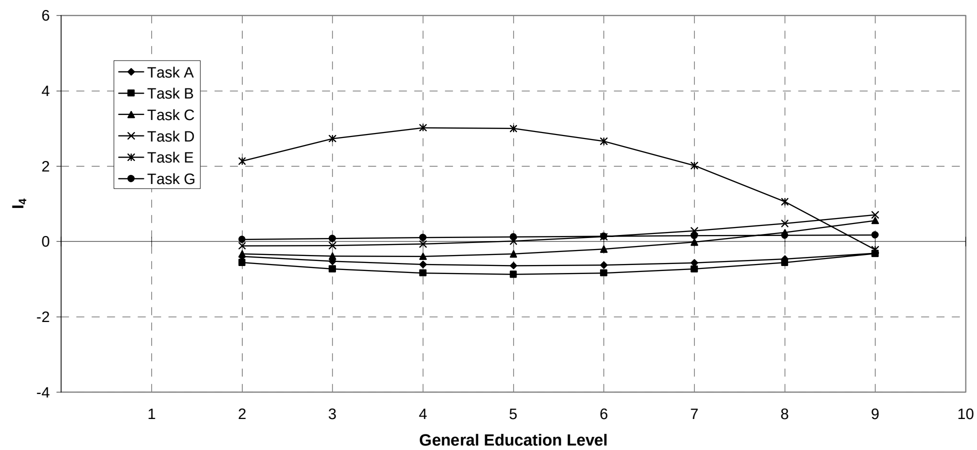


c. Substructure

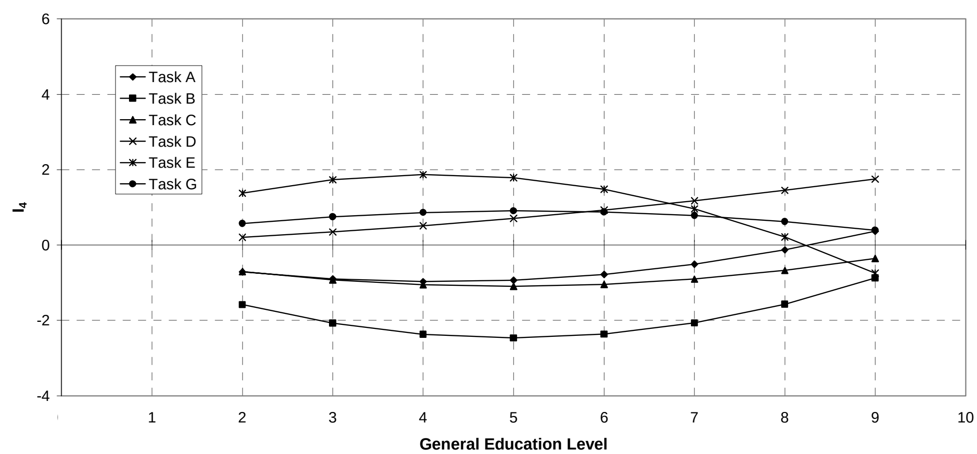
Figure 82. Influence of inspector factor Number of Annual Bridge Inspections on Condition Ratings.



a. Deck

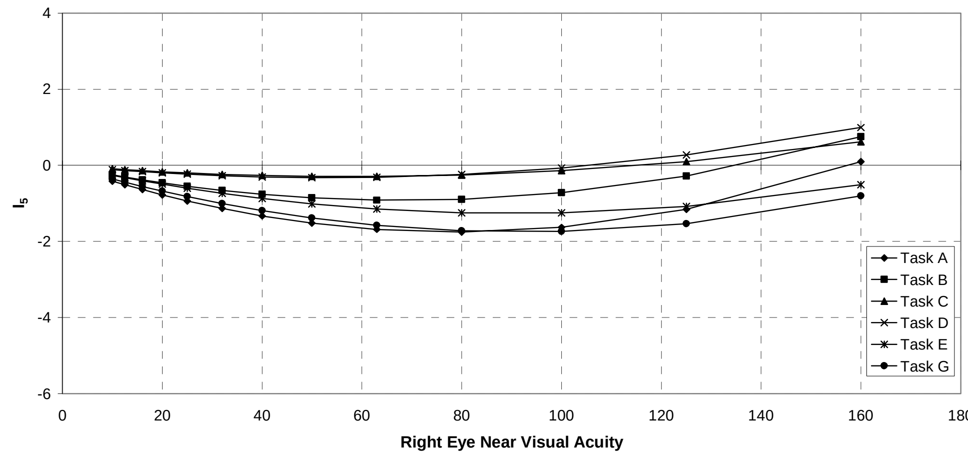


b. Superstructure

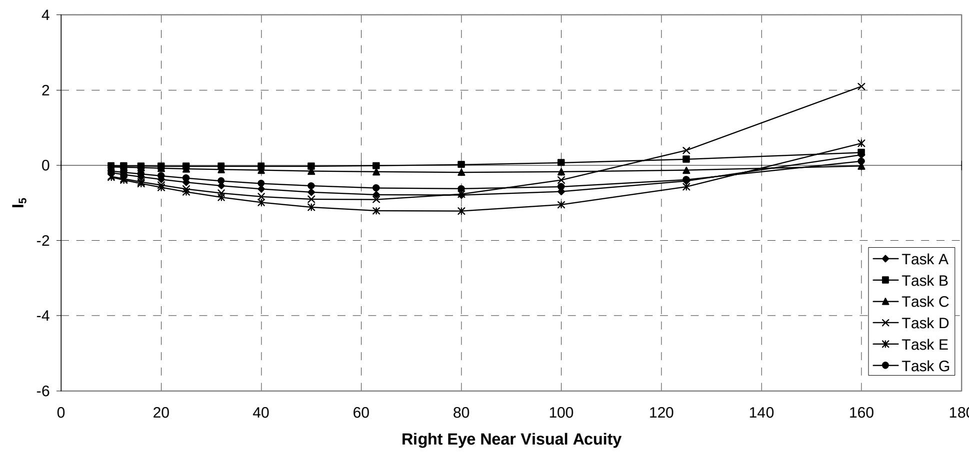


c. Substructure

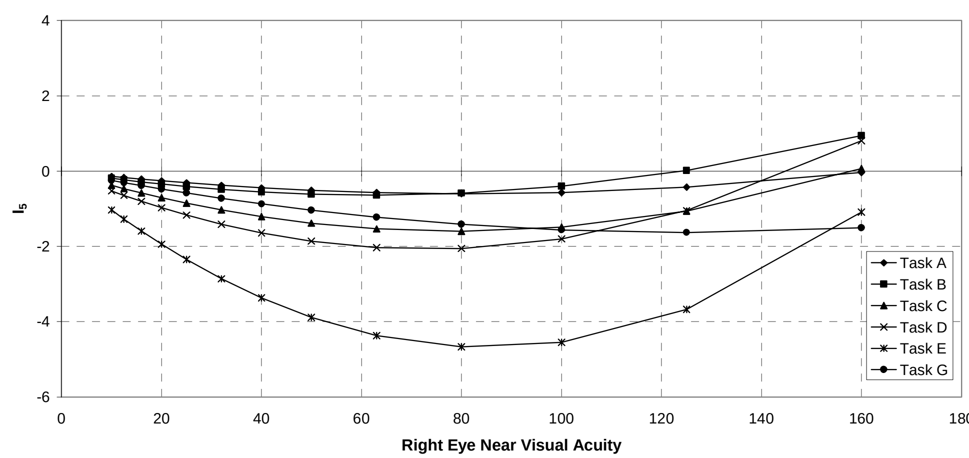
Figure 83. Influence of inspector factor General Education Level (1=Some High School, 10=Terminal Degree) on Condition Ratings.



a. Deck

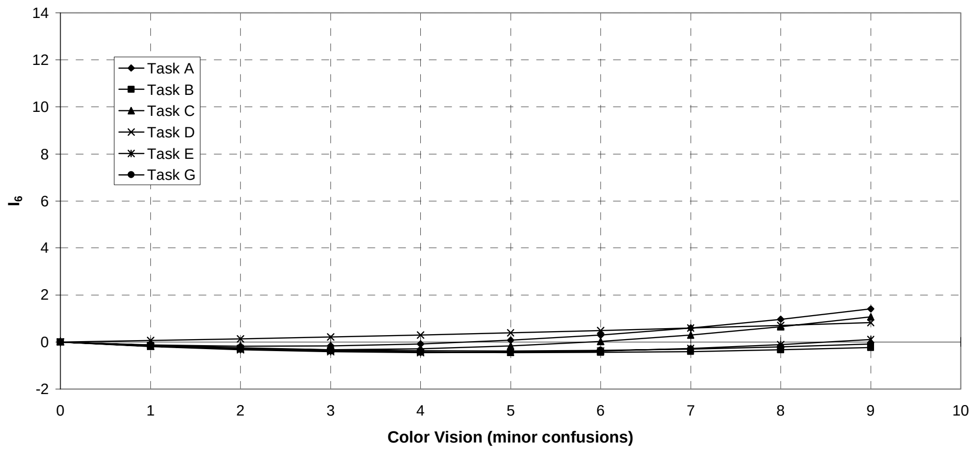


b. Superstructure

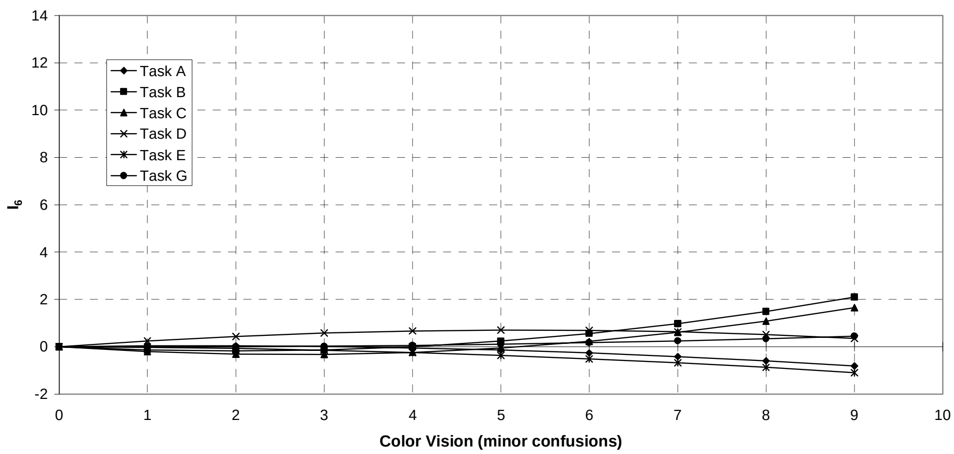


c. Substructure

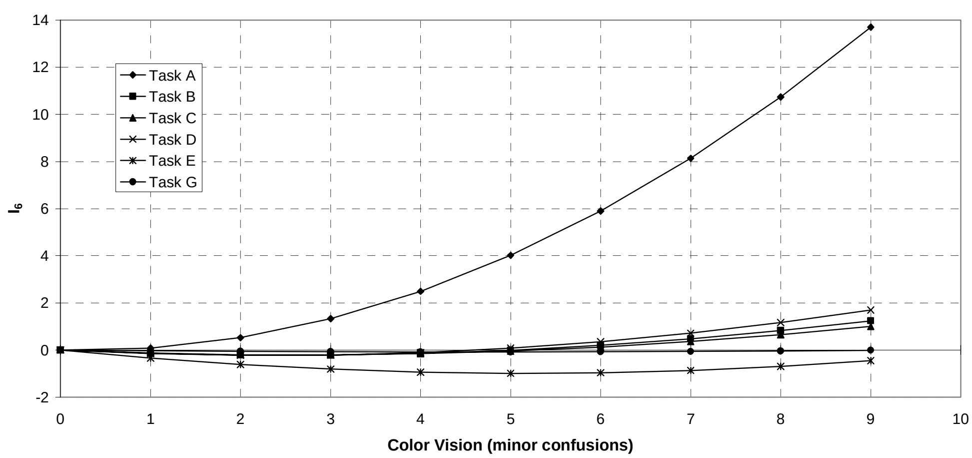
Figure 84. Influence of inspector factor Right Eye Near Visual Acuity on Condition Ratings.



a. Deck

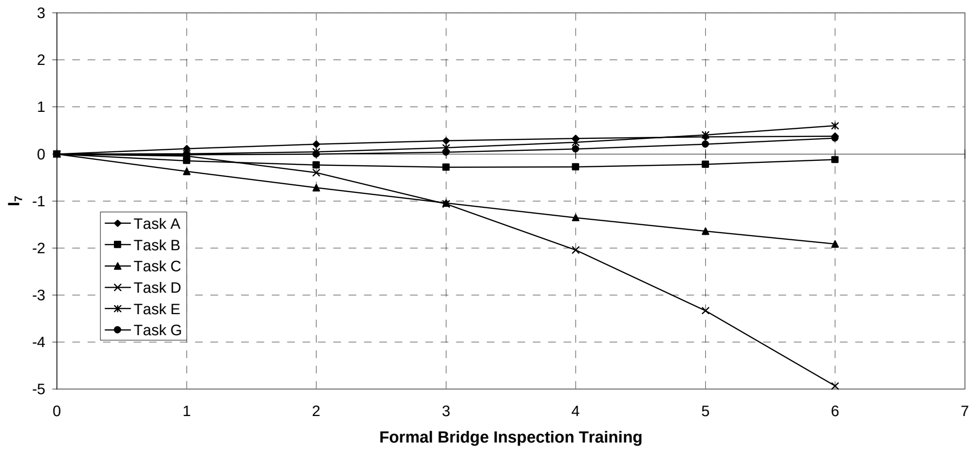


b. Superstructure

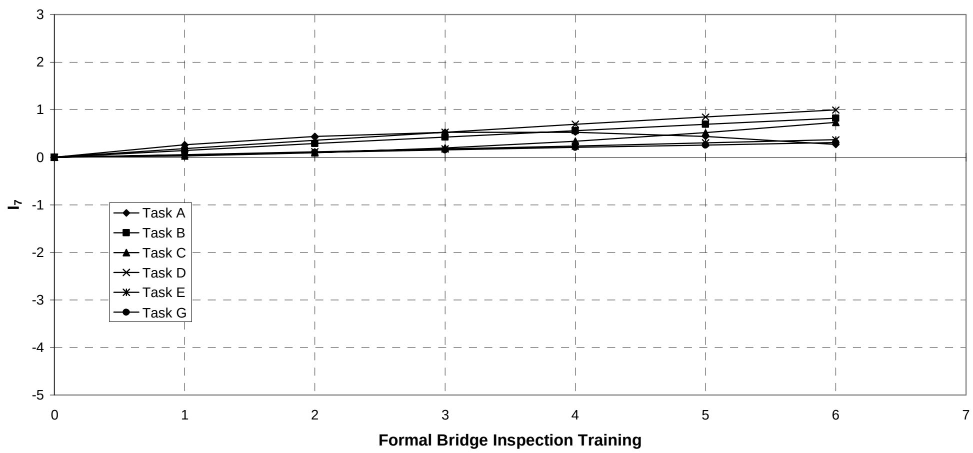


c. Substructure

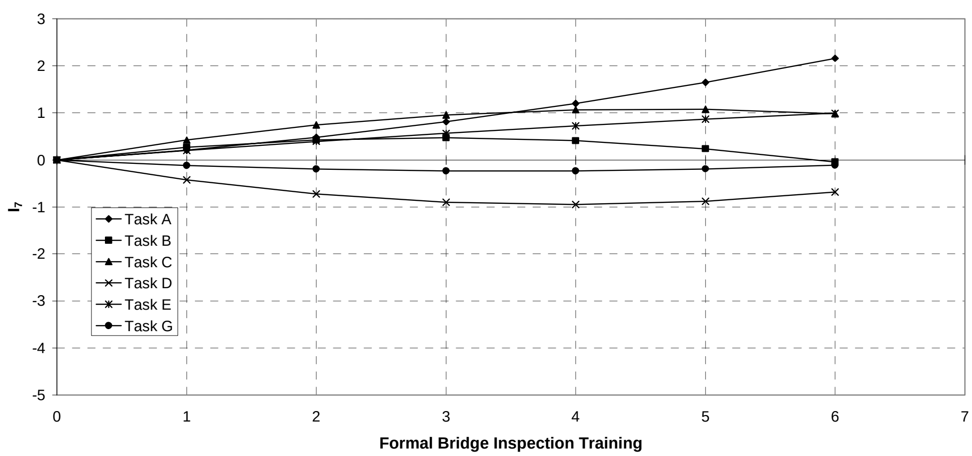
Figure 85. Influence of inspector factor Color Vision (number of minor confusions) on Condition Ratings.



a. Deck



b. Superstructure



c. Substructure

Figure 86. Influence of inspector factor Formal Bridge Inspection Training (Number of FHWA Training Courses) on Condition Ratings.

Please note that the question "What influence does this factor have on VI accuracy?" cannot be answered outright. The influence of the factors cannot be discussed in terms of a single factor. One must always remember that the interaction of the factors with one another cannot be ignored. The following hypothetical example will help to illustrate this fact:

> Assume that a sample of inspectors all had the same factors for I_1 through I_6, but they had different I_7 characteristics and one wanted to study the influence of I_7 on the inspection results. For simplicity, assume that I_7 varies linearly from 0 to 3 with a positive slope and that the condition rating for a specific element is 5. For the first scenario, assume that $y_0 + I_1 \ldots I_6 = 2$. What can be said for the first scenario is that inspectors with higher I_7 factors could be predicted to give more accurate inspection results (i.e., closer to 5). However, for the second scenario, assume that $y_0 + I_1 \ldots I_6 = 5$. It can be said for the second scenario that inspectors with lower I_7 factors could be predicted to give more accurate inspection results.

This simple example illustrates that the influence of a specific factor (e.g., I_7 in the above example) on accuracy can only be investigated if a particular known set of other factors (e.g., I_1 through I_6 in the above example) is available. However, general statements can be made if a generic set of factors is assumed to have some constant value for a sample of inspectors. In other words, if the specific value of $y_0 + I_1 \ldots I_6$ is known in the example, one could say that "with all other factors being equal, inspectors with higher I_7 factors would tend to give higher Condition Ratings." Again, note that this statement is not related to the accuracy of the Condition Rating, only the relationship of a specific factor. Finally, the issues illustrated by the example, and the issues discussed in the previous paragraphs, pertain to the correlation results in this and in subsequent sections.

INSPECTION FACTORS: As mentioned previously, the inspection factor data were collected from the pre- and post-task evaluations and through firsthand observations. Unlike the previous analyses where the inspector factors were constant for all tasks, the inspection factors could have different values for each task. In light of this, the inspection factor analyses were completed in a slightly different manner. The notable difference is that each task was analyzed independently and could have resulted in a different set of seven best-correlating inspection factors for each task. Other than this difference, the general steps for completing the analyses were the same as those previously described.

Equation 3 shows the general equation resulting from the inspection factor regression analyses. Table 100 summarizes the individual F_1 through F_7 factors for each task. Note that the factors listed for each task in table 100 are listed in rank order from the factor with the highest individual correlation coefficient to the lowest. Tables 101 through 106 give the coefficients for each element from each task and table 107 gives the resulting correlation coefficients for each equation.

$$\text{Condition Rating} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (3)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

With the exception of Wind Speed, the identified inspection factors are, again, fairly intuitive. The factors basically quantify the inspector's perception of the structure, how the inspection was completed, and the light intensity during the inspection. Another factor, Rested Level Before Task, is related to the inspector's general condition. Again, these factors are intuitive because they deal with what, how, and under what conditions the inspection was performed. Wind Speed, on the other hand, is not as intuitive. One could speculate that the Wind Speed could influence how well inspections could be performed from a ladder. However, the ladders were used very infrequently (by 24, 0, 4, and 0 percent) on the four tasks (B, C, D, and G, respectively) where Wind Speed was found to correlate.

Table 100. Inspection factors for predicting Condition Ratings.

	Task A	Task B	Task C	Task D	Task E	Task G
F_1	Reported Thoroughness Level	Reported Structure Accessibility Level	Reported Structure Maintenance Level	Wind Speed	Reported Structure Maintenance Level	Reported Structure Maintenance Level
F_2	Light Intensity Below Superstructure	Reported Structure Maintenance Level	Light Intensity Below Superstructure	Reported Structure Maintenance Level	Estimated Time for Task	Wind Speed
F_3	Reported Structure Maintenance Level	Reported Thoroughness Level	Reported Observer Influence	Reported Structure Accessibility Level	Rested Level Before Task	Reported Observer Influence
F_4	Observed Inspector Rushed Level	Wind Speed	Reported Effort Level	Reported Structure Complexity Level	Accuracy of Task at Measuring Inspection Skills	Reported Task Similarity to Normal
F_5	Reported Rushed Level	Reported Task Similarity to Normal	Reported Thoroughness Level	Time Since Similar Inspection	Reported Structure Complexity Level	Actual Time to Complete Task
F_6	Reported Task Similarity to Normal	Reported Observer Influence	Observed Inspector Focus Level	Estimated Time for Task	Actual Time to Complete Task	Reported Structure Complexity Level
F_7	Observed Inspector Focus Level	Light Intensity Deck	Wind Speed	Rested Level Before Task	Observed Inspector Rushed Level	Time Since Similar Inspection

Table 101. Task A – Equation coefficients for predicting Condition Ratings – Inspection factors.

	Element		
Coefficient	Deck	Superstructure	Substructure
y_0	4.58	5.48	-0.0148
a	0.531	-0.0705	0.203
b	-0.0527	0.0117	-0.00980
c	-4.55e-6	-2.70e-5	-3.38e-5
d	1.59e-10	2.34e-10	4.36e-10
e	-0.104	-0.0668	0.532
f	0.0160	0.0290	-0.0490
g	-0.4075	-0.0113	0.0188
h	0.0367	-1.94e-4	-1.65e-4
i	0.250	0.0348	0.213
j	-0.0273	-4.33e-3	-0.0265
k	-0.619	-0.516	-0.489
l	0.0452	0.0482	0.0455
m	0.716	0.400	1.37
n	-0.0485	-0.0322	-0.0972

Table 102. Task B – Equation coefficients for predicting Condition Ratings – Inspection factors.

	Element		
Coefficient	Deck	Superstructure	Substructure
y_0	-9.21	4.36	0.595
a	2.30	0.687	-0.412
b	-0.149	-0.0322	0.0331
c	0.332	0.202	0.8164
d	-0.0239	-0.0152	-0.0994
e	-0.533	-0.183	0.9486
f	0.0385	0.0310	-0.0731
g	0.0383	0.245	0.187
h	-2.97e-3	-2.60e-2	-1.55e-2
i	0.9565	-1.189	0.483
j	-0.0464	0.0757	-0.0471
k	1.55	0.3938	0.240
l	-0.277	-0.0545	-0.0840
m	5.97e-6	-3.49e-6	-1.11e-5
n	-2.11e-11	6.92e-11	5.98e-11

Table 103. Task C – Equation coefficients for predicting Condition Ratings – Inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	16.34	28.98	25.1
a	0.890	0.384	0.204
b	-0.0706	-0.0328	-0.0111
c	0.0105	3.83e-3	-2.14e-3
d	-1.92e-5	-8.02e-6	-2.55e-6
e	1.03	0.441	0.584
f	-0.183	-0.0476	-0.0363
g	-0.825	-0.774	-0.765
h	0.0709	0.0835	0.0656
i	-0.327	-0.523	-0.434
j	2.11e-3	3.10e-3	2.66e-3
k	-0.238	-0.817	-0.620
l	0.0173	0.0620	0.0774
m	2.20e-2	-0.0628	0.0764
n	-4.98e-4	7.69e-3	-7.61e-3

Table 104. Task D – Equation coefficients for predicting Condition Ratings – Inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	-0.496	8.16	-4.46
a	8.89e-3	1.15	0.304
b	-4.36e-3	-0.0190	-0.0542
c	0.576	0.1167	0.110
d	-0.0638	-0.0125	-0.0324
e	1.42	0.6196	-0.0557
f	-0.104	-0.0601	-0.0064
g	-0.0095	-0.139	1.26
h	0.0110	0.0232	-0.220
i	0.0079	0.0269	0.0074
j	-4.22e-5	-1.22e-4	-5.75e-5
k	0.0090	-0.0076	2.21e-3
l	-4.54e-5	-1.04e-5	1.23e-5
m	-0.341	-1.67	2.83
n	0.0323	0.139	-0.203

Table 105. Task E – Equation coefficients for predicting Condition Ratings – Inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	4.35	-8.43	-7.82
a	0.139	0.185	0.252
b	0.0118	-0.0053	-0.0187
c	0.0105	0.0126	0.0061
d	-2.03e-5	-2.02e-5	-9.06e-7
e	0.0436	4.30	3.93
f	-0.0181	-0.326	-0.290
g	-0.142	-0.285	-0.394
h	0.0136	0.0199	0.0237
i	0.0492	-0.510	0.148
j	4.11e-3	0.0559	-0.0078
k	-0.0731	-0.0239	-0.0618
l	7.97e-4	4.50e-4	5.69e-4
m	0.558	0.520	1.13
n	-0.0742	0.0621	-0.161

Table 106. Task G – Equation coefficients for predicting Condition Ratings – Inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	4.86	1.59	5.16
a	0.926	1.66	0.595
b	-0.0608	-0.103	-0.0358
c	-0.0889	0.0752	-0.092
d	4.79e-3	3.05e-3	5.29e-3
e	-0.256	0.0251	-0.104
f	0.0568	-0.0277	0.0269
g	-0.0146	0.0216	0.152
h	2.51e-4	-0.0091	-0.0137
i	-0.0437	-2.01e-3	-0.0317
j	3.76e-4	-2.15e-5	2.13e-4
k	-0.0832	-0.290	0.0553
l	0.0212	0.0271	4.65e-3
m	2.25e-3	0.0062	0.0073
n	1.50e-5	-3.24e-5	-3.76e-5

Table 107. Correlation coefficients for influence of inspection factors on Condition Ratings.

	Task					
Element	A	B	C	D	E	G
Deck	0.69	0.63	0.77	0.68	0.58	0.61
Superstructure	0.59	0.58	0.53	0.74	0.67	0.77
Substructure	0.70	0.73	0.63	0.54	0.67	0.54

Figures L1 through L18 in Appendix L in Volume II show the general trends of the I_i equations given in Equation 3. Note that not all tasks will appear in all figures since the inspection factors varied for each task. Some interesting trends can be observed in these figures. First, when a certain factor was found to only correlate with a specific task, the relationship of that factor to the deck, superstructure, and substructure Condition Ratings generally was consistent between the elements. However, when a factor was found to correlate with two tasks, the influence of that factor was not, in general, consistent for the two tasks. Finally, when a factor was found to correlate with more than two tasks, there was greater consistency in the influence of that factor across the tasks. Also note that the ambient light intensity had the greatest influence on the deck Condition Rating and less of an influence on the Condition Rating of the superstructure and substructure. In addition, note that feeling moderately rushed tended to have the greatest influence on the assignment of the Condition Rating regardless of the element type. With respect to Reported Structure Accessibility, it appears that this factor influences the deck and superstructure Condition Ratings the most. Similar to Reported Rushed Level, the influence of Reported Effort Level was greatest at moderate levels.

COMBINED INSPECTOR/INSPECTION FACTORS: In this section, equations for predicting the Condition Ratings in terms of the combined inspector/inspection factors will be presented. A similar procedure to that for determining the inspection factors was used in the inspector and inspection factors analyses.

Equation 4 shows the general equation resulting from the regression analyses. Table 108 summarizes the individual F_1 through F_7 factors for each task. As before, note that the factors for each task in table 108 are in rank order from the factor with the highest individual correlation coefficient to the lowest. Tables 109 through 114 give the equation coefficients for each element from each task and table 115 gives the resulting correlation coefficients for each equation.

Table 108. Combined inspector/inspection factors for predicting Condition Ratings.

	Task A	Task B	Task C	Task D	Task E	Task G
F_1	Reported Fear of Traffic	Reported Structure Accessibility Level	Reported Structure Maintenance Level	Reported Fear of Traffic	Reported Structure Maintenance Level	Reported Structure Maintenance Level
F_2	Reported Thoroughness Level	Reported Fear of Traffic	Reported Fear of Traffic	Wind Speed	Estimated Time for Task	Reported Fear of Traffic
F_3	Light Intensity Below Superstructure	Reported Structure Maintenance Level	Light Intensity Below Superstructure	Reported Structure Maintenance Level	Rested Level Before Task	Wind Speed
F_4	Reported Structure Maintenance Level	Reported Thoroughness Level	General Mental Condition	General Mental Condition	Reported Fear of Traffic	Reported Observer Influence
F_5	Observed Inspector Rushed Level	Wind Speed	Number of Annual Bridge Inspections	Reported Structure Accessibility Level	Accuracy of Task at Measuring Inspection Skills	General Mental Condition
F_6	Reported Rushed Level	Reported Task Similarity to Normal	General Education Level	Reported Structure Complexity Level	Reported Structure Complexity Level	Number of Annual Bridge Inspections
F_7	General Mental Condition	Reported Observer Influence	Right Eye Near Visual Acuity	Number of Annual Bridge Inspections	Actual Time to Complete Task	General Education Level

Table 109. Task A – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	1.30	7.66	-2.09
a	1.76	0.439	2.79
b	-0.238	-0.0052	0.448
c	-0.0425	-0.0767	-0.197
d	-2.10e-3	0.0087	0.0076
e	-8.75e-6	-2.60e-5	-2.45e-5
f	1.35e-10	1.89e-10	2.75e-10
g	0.0884	0.0057	0.437
h	-0.0090	0.0173	-0.0444
i	-0.629	-0.0672	-0.186
j	0.0547	0.0012	0.0205
k	0.229	-0.0173	0.0915
l	-0.0282	8.04e-5	-0.0202
m	1.69	-1.56	1.98
n	-0.230	0.221	-0.245

Table 110. Task B – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	-10.4	3.37	-1.41
a	1.38	0.178	-0.492
b	-0.0944	-9.84e-4	0.0414
c	1.69	0.611	0.105
d	-0.217	-0.0413	0.0198
e	0.628	0.357	0.829
f	-0.0624	-0.0339	-0.0990
g	-0.227	-0.0563	0.612
h	0.0118	0.0215	-0.0445
i	5.66e-3	0.237	0.167
j	-1.35e-3	-0.0267	-0.0160
k	1.45	-0.811	1.14
l	-0.0827	0.0480	-0.0918
m	1.11	0.362	0.298
n	-0.196	-0.0421	-0.0895

Table 111. Task C – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	-1.78	3.74	-6.77
a	0.279	0.553	0.876
b	-0.0073	-0.0539	-0.0942
c	-0.134	1.16	4.99
d	0.0953	-0.112	-0.8936
e	6.91e-3	1.32e-3	3.75e-3
f	-1.49e-5	-3.66e-6	-9.16e-6
g	2.28	-0.392	3.34
h	-0.3358	-0.0074	-0.450
i	2.53e-3	-0.0039	-4.13e-3
j	-2.69e-6	4.10e-6	3.93e-6
k	0.165	-0.0192	-0.423
l	-0.0094	-0.00237	0.0363
m	0.0136	-0.0094	-0.0313
n	-2.83e-5	5.74e-5	2.01e-4

Table 112. Task D – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

Coefficient	Element		
	Deck	Superstructure	Substructure
y_0	-10.5	-3.17	-8.68
a	3.62	-1.75	-0.909
b	-0.645	0.437	0.130
c	0.117	0.864	0.168
d	-6.22e-3	-0.178	-4.21e-3
e	0.907	0.132	0.131
f	-0.0844	-0.0313	-0.0185
g	6.03	4.49	9.37
h	-0.835	-0.455	-1.31
i	-0.229	-0.419	0.168
j	0.0128	0.0248	-0.0236
k	-0.582	0.0144	0.695
l	0.0877	-0.364	-0.112
m	-1.35e-3	0.0050	-0.0064
n	7.19e-7	-3.46e-6	5.25e-6

Table 113. Task E – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

	Element		
Coefficient	Deck	Superstructure	Substructure
y_0	6.98	7.55	11.5
a	0.343	0.314	0.702
b	-0.0130	-0.0212	-0.0714
c	0.0064	0.0128	5.89e-4
d	-1.09e-5	-2.43e-5	1.27e-5
e	0.132	4.34	3.58
f	0.0208	-0.326	-0.261
g	-2.96	-1.51	0.410
h	0.649	0.308	0.0568
i	-0.0377	-0.347	-0.328
j	-0.0025	0.0201	0.0119
k	0.0091	-0.541	0.112
l	0.0088	0.0586	-0.0080
m	-0.0308	0.0480	0.153
n	3.39e-4	-2.52e-4	-1.78e-3

Table 114. Task G – Equation coefficients for predicting Condition Ratings – Combined inspector/inspection factors.

	Element		
Coefficient	Deck	Superstructure	Substructure
y_0	2.68	0.426	7.07
a	0.776	1.76	0.139
b	-0.0527	-0.108	-1.16e-3
c	0.122	0.0717	-1.33
d	0.0294	-0.0337	0.273
e	0.0607	-0.0640	0.0375
f	2.09e-3	3.22e-3	1.89e-3
g	-0.507	-0.0135	-0.167
h	0.0877	-0.0173	0.0332
i	0.917	-0.274	0.201
j	-0.104	0.0483	-0.0577
k	6.86e-5	8.57e-4	7.35e-4
l	-2.77e-7	-9.74e-7	7.42e-7
m	0.0443	-0.0937	0.388
n	2.58e-4	0.0078	-0.0381

Table 115. Correlation coefficients for the influence of combined inspector/inspection factors on Condition Ratings.

	Task					
Element	A	B	C	D	E	G
Deck	0.74	0.68	0.77	0.77	0.67	0.51
Superstructure	0.61	0.85	0.66	0.65	0.67	0.72
Substructure	0.75	0.69	0.71	0.60	0.66	0.52

$$\text{Condition Rating} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (4)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

If one compares table 108 with table 100 and the inspector factor analysis identified previously, it is clear that the same factors reoccur for the combined inspector/inspection factors analyses. Therefore, the previous discussion about the specific factors holds true here as well.

Note from table 108 that all tasks have both inspector and inspection factors in their respective equations. In fact, the minimum number of inspector factors is one (Task E) and the minimum number of inspection factors is two (Task C). On average, there were 2-2/3 inspector factors and 4-1/3 inspection factors for each task. The general trend resulting from combining the inspector and inspection factors was to generally increase the correlation coefficients for each task. Note, however, that the correlation coefficient may not have increased for each element, only that the overall effect was to increase the correlation. These results indicate that to best predict Condition Rating results, one must consider both the inspector and inspection factors.

Figures L19 through L37 in Appendix L, in Volume II show the general trends of the I_i equations given previously. Note that not all tasks will appear in all figures since each task may have a different set of combined inspector/inspection factors. The resulting general trend from combining the inspector and inspection factors to predict the Condition Ratings was to increase the consistency of the equation trends for different tasks and to decrease the consistency of the equation trends for different element types. Specifically, note the influence of Reported Fear of Traffic on the substructure Condition Rating, indicating that inspectors may have the greatest fear of being hit by traffic below the bridge being inspected. Also note the consistency of the influence of General Mental Condition, indicating that the influence of this factor is independent of the structure being inspected.

5.2.3.2.2. Deviation From Reference (DFR)

The regression analysis for predicting the DFR will be presented in two primary sections, each containing three subsections. The first primary section will present the regression analysis for each bridge element and the second will present the results without regard to the element type. The three subsections within each primary section present specific results in terms of the inspector factors, the inspection factors, and the combined inspector/inspection factors.

PRIMARY BRIDGE ELEMENTS: In this section, the relationship between the measured factors and the deck, superstructure, and substructure DFR data will be discussed. The results are presented in the same format as used previously. First, the influence of the inspector factors alone are presented; second, the influence of the inspection factors alone are presented; and finally, the combined inspector/inspection factors are discussed together.

Inspector Factors: The general procedure for establishing the relationships is exactly the same as was used in the previous discussion. The only difference is that the equations predict the DFR instead of the Condition Ratings. The inspector factors can be combined into the nonlinear, multivariate equation given in equation 5:

$$\text{DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (5)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$$I_5 = i(F_5) + j(F_5)^2$$
$$I_6 = k(F_6) + l(F_6)^2$$
$$I_7 = m(F_7) + n(F_7)^2$$

with: F_1 = Reported Fear of Traffic
F_2 = Color Vision (major confusions)
F_3 = Left Eye Near Visual Acuity
F_4 = Formal Bridge Inspection Training
F_5 = Quality of Relationship With Supervisor
F_6 = Left Eye Distance Visual Acuity
F_7 = Reported Fear of Enclosed Spaces

Note that most of the factors in Equation 5 are the same as had been used previously. However, note that the vision assessments have changed from the right eye to the left and from the number of minor confusions to the number of major confusions. This shift indicates that inspector vision in both eyes and both color vision assessments may be important to Routine Inspection results because attributes for both eyes have been used in the regression analysis.

Values for the equation coefficients for the deck, superstructure, and substructure are given in table 116. The correlation coefficients for these equations are 0.46, 0.34, and 0.41, respectively. Figures L38 through L44 in Appendix L in Volume II illustrate the relationship of each of the factors with the DFR for the deck, superstructure, and substructure. Also note that these graphs represent the equations for I_1 through I_7 given above. With the exception of the color vision factor, there is a high degree of consistency in the relationship of each factor with regard to the element type. One possible explanation of this lack of consistency in the color vision factor could be that different material types are used for the superstructures, whereas the decks and substructures were all concrete.

Table 116. Coefficients for DFR equations – Inspector factors.

Coefficient	Bridge Element		
	Deck	Superstructure	Substructure
y_0	-4.80	-7.19	-10.2
a	1.90	0.934	1.91
b	-0.326	-0.134	-0.343
c	-0.0346	0.0066	-0.0368
d	1.64e-4	-1.39e-4	6.42e-4
e	-0.0142	-0.0081	-3.08e-3
f	3.25e-5	3.85e-6	-7.70e-5
g	0.272	0.252	0.311
h	-0.0310	-0.0276	-0.0395
i	2.12	2.86	3.92
j	-0.283	-0.348	-0.473
k	-0.0364	-0.0159	-0.0400
l	1.76e-4	1.25e-4	5.08e-4
m	-0.709	0.0261	-0.385
n	0.153	0.0085	0.106

Inspection Factors: The procedure for establishing the relationship of the inspection factors to the DFR was exactly the same as that used to determine Equation 5. As before, the inspection factors can be combined into the nonlinear, multivariate equation given as Equation 6:

$$\mathrm{DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (6)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Structure Accessibility Level

F_2 = Reported Structure Maintenance Level

F_3 = Reported Structure Complexity Level

F_4 = Light Intensity on Deck

F_5 = Light Intensity Below Superstructure

F_6 = Reported Rushed Level

F_7 = Wind Speed

Similar inspection factors to those identified previously were again identified here. With the exception of Wind Speed, the probable relationship of these factors with the DFR is again intuitive. These factors quantify what was inspected, under what conditions the inspection was completed, and how hastily the inspection was completed.

Values for the equation coefficients are given in table 117. The correlation coefficients obtained for these equations are 0.40, 0.49, and 0.44, respectively. Figures L45 through L51 in Appendix L in Volume II illustrate the relationship of each of the factors with the DFR for the deck, superstructure, and substructure. With the exception of Reported Maintenance Level, Reported

Table 117. Coefficients for DFR equations – Inspection factors.

	Bridge Element		
Coefficient	Deck	Superstructure	Substructure
y_0	-1.38	-1.62	-0.557
a	0.303	0.0526	-0.0257
b	-0.0204	0.0067	0.0083
c	0.224	0.155	0.379
d	-0.0144	-3.09e-3	-0.0414
e	0.205	0.0212	-0.262
f	-0.0226	-0.0073	0.0196
g	-1.53e-5	5.06e-6	-4.79e-7
h	1.36e-10	-3.71e-11	-9.41e-12
i	-1.18e-5	-3.18e-6	-4.45e-6
j	2.36e-10	3.46e-11	1.33e-10
k	0.0870	0.284	0.181
l	-0.0142	-0.0244	-0.0265
m	0.0512	0.0505	0.0721
n	-2.28e-3	-2.34e-3	-3.28e-3

Structure Complexity Level, and the Light Intensity on the Deck, the relationships are relatively consistent for various elements. The relationship for the Reported Maintenance Level showed a different relationship for the substructure, as one would expect, due to there being generally less deterioration in the substructure. With regard to complexity, the difference in the relationships can probably be attributed to the fact that inspector complexity assessments were probably heavily influenced by the superstructure and less so by the substructure and deck. In addition, the influence of the light intensity on the deck had a significantly different influence on the deck inspection, as one would expect.

Combined Inspector/Inspection Factors: The inspector and inspection factors can also be combined using the previously described process into the nonlinear, multivariate equation given below as Equation 7:

$$\mathrm{DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \tag{7}$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Structure Accessibility Level

F_2 = Reported Fear of Traffic

F_3 = Reported Structure Maintenance Level

F_4 = Reported Structure Complexity Level

F_5 = Light Intensity on Deck

F_6 = Color Vision (major confusions)

F_7 = Light Intensity Below Superstructure

Values for the equation coefficients are given in table 118. The correlation coefficients obtained for these equations are 0.54, 0.49, and 0.48, respectively. Figures L52 through L58 in Appendix L in Volume II illustrate the predicted influence of each of the factors on the DFR for each element. When the inspector and inspection factors are evaluated together, the trends discussed previously are generally repeated.

Table 118. Coefficients for DFR equations – Combined inspector/inspection factors.

	Bridge Element		
Coefficient	Deck	Superstructure	Substructure
y_0	-3.68	-1.52	-1.78
a	0.226	-0.0512	-0.127
b	-0.0164	0.0116	0.0148
c	1.83	0.417	1.20
d	-0.273	-0.0120	-0.160
e	0.262	0.117	0.366
f	-0.0177	2.81e-3	-0.0375
g	0.198	0.0559	-0.279
h	-0.0216	-0.0113	0.0202
i	-1.52e-5	3.24e-6	-7.59e-7
j	1.42e-10	-2.32e-11	1.57e-12
k	-0.0276	-0.0109	-0.0371
l	1.71e-4	6.26e-4	8.61e-4
m	-1.72e-5	4.36e-6	-1.25e-5
n	2.77e-10	-5.45e-11	2.23e-10

GENERAL INSPECTION: In the previous analyses, the results were specific either to a task completed during this investigation or to a specific element type. In this section, the DFR data are analyzed without regard to the specific task or the element type. This information leads to the establishment of a set of factors found to correlate with the sample bridge inspection results in general. The results presented here can be considered, when compared with respect to the results from the previous sections, to be the most useful for general applications. This stems from the fact that these results are independent of the task that was completed, the type of element being evaluated, and the relative condition of the element. In other words, these results describe the general relationship of those factors found to have the greatest correlation with overall Routine Inspection. In light of this, minimal discussion beyond presenting the results is given. Note that all findings obtained in this section resulted from the same procedure described previously.

Inspector Factors: The inspector factors can be combined into a nonlinear, multivariate equation similar to the ones presented previously. This equation is given below as Equation 8:

$$\text{General DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (8)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Fear of Traffic

F_2 = Color Vision (major confusions)

F_3 = Left Eye Near Visual Acuity

F_4 = Formal Bridge Inspection Training

F_5 = Left Eye Distance Visual Acuity

F_6 = General Mental Focus

F_7 = Reported Fear of Enclosed Spaces

Values for the equation coefficients are given in table 119. The correlation coefficient obtained for this equation is 0.35. Figures L59 through L65 in Appendix L in Volume II illustrate the influence of each of the factors on the general DFR.

Inspection Factors: The inspection factors can be combined into a nonlinear, multivariate equation similar to the ones presented previously. This equation is given below as Equation 9:

$$\text{General DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \qquad (9)$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

Table 119. Coefficients for general DFR equation – Inspector factors.

Coefficient	General DFR
y_0	4.14
a	0.923
b	-0.131
c	-0.110
d	0.0194
e	-0.0210
f	2.13e-4
g	0.168
h	-0.0143
i	-0.0170
j	2.24e-5
k	-2.08
l	0.245
m	-0.750
n	0.149

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Structure Accessibility Level

F_2 = Reported Structure Maintenance Level

F_3 = Light Intensity on Deck

F_4 = Light Intensity Below Superstructure

F_5 = Reported Structure Complexity Level

F_6 = Wind Speed

F_7 = Reported Rushed Level

Values for the coefficients "a" through "n" are given in table 120. The correlation coefficient obtained for this equation is 0.35. Figures L66 through L72 in Appendix L in Volume II illustrate the influence of each of the factors on the general DFR.

Table 120. Coefficients for general DFR equation – Inspection factors.

Coefficient	General DFR
y_0	-1.15
a	0.102
b	-1.37e-3
c	0.253
d	-0.0197
e	-43.75e-6
f	3.14e-11
g	-6.51e-6
h	1.36e-10
i	-0.0139
j	-3.16e-3
k	0.0577
l	-2.59e-3
m	0.185
n	-0.0218

Combined Inspector/Inspection Factors: The inspector and inspection factors can be combined into a nonlinear, multivariate equation similar to the ones presented previously. This equation is given below as Equation 10:

$$\text{General DFR} = y_0 + I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 \tag{10}$$

where: $I_1 = a(F_1) + b(F_1)^2$

$I_2 = c(F_2) + d(F_2)^2$

$I_3 = e(F_3) + f(F_3)^2$

$I_4 = g(F_4) + h(F_4)^2$

$I_5 = i(F_5) + j(F_5)^2$

$I_6 = k(F_6) + l(F_6)^2$

$I_7 = m(F_7) + n(F_7)^2$

with: F_1 = Reported Structure Accessibility Level

F_2 = Reported Fear of Traffic

F_3 = Reported Structure Maintenance Level

F_4 = Light Intensity on Deck

F_5 = Color Vision (major confusions)

F_6 = Light Intensity Below Superstructure

F_7 = Left Eye Near Visual Acuity

Values for the general equation coefficients are given in table 121. The correlation coefficient obtained for this equation is 0.45. Figures L75 through L79 in Appendix L in Volume II illustrate the influence of each of the factors on the general DFR.

Table 121. Coefficients for general DFR equation – Combined inspector/inspection factors.

Coefficient	General DFR
y_0	-1.99
a	-0.0356
b	0.0065
c	1.21
d	-0.162
e	0.222
f	-0.0131
g	-1.48e-7
h	1.86e-12
i	-0.112
j	0.0141
k	-1.54e-5
l	1.93e-10
m	-0.0127
n	1.04e-4

5.2.4. Task D Inspector Photographic Documentation

During Task D, inspectors were asked to use a digital camera to document their findings in addition to their field notes and Condition Ratings. There were two reasons for asking inspectors for this type of documentation: (1) to investigate what type of visual documentation is typically collected and (2) to study whether obtaining photographic documentation correlates with the Condition Rating results.

5.2.4.1. TYPES OF INSPECTOR PHOTOGRAPHS

The inspector photographs could generally be grouped into 18 different types of photographs. Of these 18 photographs, 13 have been identified by the NDEVC as the minimum photographs required to fully document the bridge. The other five photograph types are either outside of the scope of the inspection (e.g., the approach rail) or supplement deterioration shown in other photographs. Figures 87 through 104 show examples of the typical photograph types.

On average, each inspector took just over 7 photographs (standard deviation of 3.8), with a maximum of 19 and a minimum of 1. Table 122 summarizes the frequency with which each of these 18 photographs was taken. Note, however, that many inspectors may have taken more than one photograph of the same item, a fact that is not represented by the data in Table 122. It is clear from Table 122 that the photographs of the deck joint deterioration, the deterioration of the parapet, the south elevation view, and the general approach view were the most common photographs. All other photographs were taken by fewer than half of the inspectors. Also, while more than 30 of the inspectors took a photograph of the south elevation, only 5 inspectors took a similar photograph of the north elevation. This is probably attributed to the difficult access to the northern elevation discussed previously. The wide variability in the type and number of photographs taken may illustrate differences in inspection agency documentation policies. Note that figures 89 through 91 show the same type of deterioration in multiple locations and one could argue that all three are not necessary.

5.2.4.2. CORRELATION OF INSPECTOR PHOTOGRAPHS WITH CONDITION RATINGS

It was speculated that an inspector who provided more photographic documentation may have identified more deficiencies, which may lead to a lower Condition Rating. Two techniques were used to assess this relationship. First, the total number of the previously mentioned photographs, minus any repeats, that each inspector took was compared with their Condition Ratings for the deck, superstructure, and substructure. In the same manner, the number of the 13 photographs identified by the NDEVC discussed previously that were taken was also analyzed with respect to the Condition Ratings. For the second technique, the relationship between specific photographs was investigated by comparing the average Condition Rating for inspectors taking each

Figure 87. Inspector Photograph 1 – Longitudinal cracking in southern face of superstructure.

Figure 88. Inspector Photograph 2 – Typical underside deck cracking.

Figure 89. Inspector Photograph 3 – West backwall longitudinal joint deterioration.

Figure 90. Inspector Photograph 4 – Underside deck longitudinal joint deterioration.

Figure 91. Inspector Photograph 5 – East backwall longitudinal joint deterioration.

Figure 92. Inspector Photograph 6 – Failed overhead sign connection.

Figure 93. Inspector Photograph 7 – Hole in east approach.

Figure 94. Inspector Photograph 8 – Typical parapet concrete deterioration and exposed reinforcement.

Figure 95. Inspector Photograph 9 – Localized spalling in northeast wingwall.

Figure 96. Inspector Photograph 10 – Typical wearing surface deterioration.

Figure 97. Inspector Photograph 11 – North elevation view.

Figure 98. Inspector Photograph 12 – General approach view.

Figure 99. Inspector Photograph 13 – South elevation view.

Figure 100. Inspector Photograph 14 – General backwall condition.

Figure 101. Inspector Photograph 15 – General wingwall condition.

Figure 102. Inspector Photograph 16 – General approach rail condition.

Figure 103. Inspector Photograph 17 – General photograph of bridge underside.

Figure 104. Inspector Photograph 18 – Localized soil erosion.

Table 122. Frequency of specific photographic documentation.

Photograph	Inspectors
1	17 (35%)
2	18 (37%)
3	12 (24%)
4	45 (92%)
5	13 (27%)
6	2 (4%)
7	15 (31%)
8	40 (82%)
9	2 (4%)
10	20 (41%)
11	5 (10%)
12	31 (63%)
13	31 (63%)
14	3 (6%)
15	6 (12%)
16	10 (20%)
17	3 (6%)
18	1 (2%)

photograph with the overall average Condition Rating. The goal of this type of analysis was to determine whether the average Condition Ratings for the two groups were statistically different.

Regardless of the type of analysis used, no correlation between the visual documentation and the Condition Ratings could be established. Specifically, with regard to the number of photographs taken, there were no overall differences in Condition Ratings for inspectors who took different quantities of photographs. Furthermore, the comparison of the primary element Condition Ratings for inspectors who took each of the pictures versus the entire sample of inspectors showed that there were minor differences. However, the t-test used previously indicated that, in all cases, there was no statistical difference between the inspectors who took pictures and those who did not.

This analysis does not imply that visual documentation is not useful or valuable. Certainly, tools such as cameras allow an inspector to document inspection results more thoroughly and accurately. This analysis simply indicates that the number and type of photographs taken during Task D did not correlate with the Task D Condition Ratings.

5.2.5. Field Inspection Notes

This section summarizes notes collected by inspectors during the six Routine Inspection tasks. Typically, inspection notes are used to supplement or to reinforce assigned Condition Ratings. Although the inspectors participating in this study may have taken a large number of inspection notes during the inspection tasks, this analysis will focus only on a small set of notes deemed to be of principal importance. These notes generally describe poorly rated elements.

This discussion is presented in four sections. First, the specific notes that were analyzed are presented. Second, general information about the inspector note-taking performance is discussed. Third, the relationship between the inspector factors and note-taking performance is then presented. Finally, the correlation of note-taking with the primary element Condition Ratings is discussed.

5.2.5.1. EXPECTED NOTES

Although there are many possible field inspection notes that could be generated, a limited number of important notes were selected for these analyses. These notes were typically provided by the inspectors to describe low Condition Ratings. The specific notes analyzed for each task are summarized in table 123 and pictures of the deterioration they describe are shown in figures 105 through 124. Note that the text in table 123 is a typical description of the deterioration that the inspectors were expected to note. The inspectors were not, for analysis purposes, required to have the exact verbiage shown in the table to receive credit for taking a respective note.

However, general notes (i.e., corrosion) were not permitted if specific notes (i.e., corrosion of end floor beam) were expected. The Note Numbers shown in table 123 will be used in subsequent discussions to refer to these notes.

Table 123. Inspection field notes analyzed.

Task	Note Number	Note
A	A1	Underside deck cracking and/or efflorescence
	A2	Heavy corrosion of end floor beam
	A3	Minor to moderate corrosion of stringer web at deck interface
	A4	Full-height vertical crack in north abutment
	A5	Impact damage to superstructure stiffeners
B	B1	Severe deterioration of wearing surface
	B2	Severe parapet deterioration
	B3	T-beam deterioration
	B4	Full-length horizontal crack in west abutment
C	C1	Severe deterioration of wearing surface
	C2	T-beam deterioration
	C3	Three-quarter length transverse crack in east abutment
D	D1	Severe deterioration of wearing surface
	D2	Severe parapet deterioration
	D3	Longitudinal joint deterioration
E	E1	Severe deterioration of wearing surface
	E2	Underside deck cracking and/or efflorescence
	E3	Minor to moderate superstructure corrosion
	E4	Impact damage to south fascia girder
G	G1	Moderate to severe corrosion of abutment bearings

5.2.5.2. INSPECTOR NOTES

This section will summarize the inspector performance at taking the specific notes outlined in table 123. The data for each task will be presented in a task-by-task format.

5.2.5.2.1. Task A

Of the five field notes investigated for Task A, the inspectors took an average of 3.0 notes (standard deviation of 1.1), with a minimum of zero and a maximum of five. Table 124 summarizes the frequency with which individual Task A notes were taken and table 125 gives the frequency distribution with which different numbers of Task A notes were taken.

Figure 105. Deterioration described by Note A1 – Underside deck cracking and/or efflorescence.

Figure 106. Deterioration described by Note A2 – Heavy corrosion of end floor beam.

Figure 107. Deterioration described by Note A3 – Minor to moderate corrosion of stringer web at deck interface.

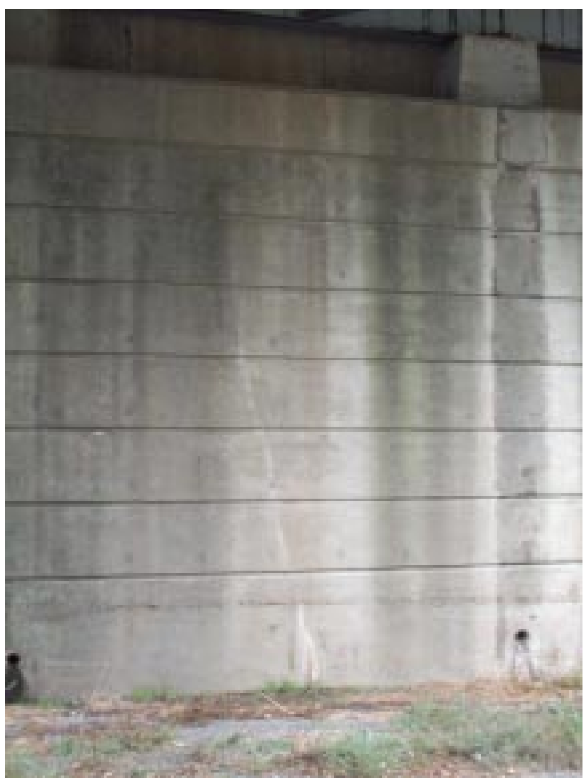


Figure 108. Deterioration described by Note A4 – Full-height vertical crack in north abutment.

Figure 109. Deterioration described by Note A5 – Impact damage to superstructure stiffeners.

Figure 110. Deterioration described by Note B1 – Severe deterioration of wearing surface.

Figure 111. Deterioration described by Note B2 – Severe parapet deterioration.

Figure 112. Deterioration described by Note B3 – T-beam deterioration.

Figure 113. Deterioration described by Note B4 – Full-length horizontal crack.

Figure 114. Deterioration described by Note C1 – Severe deterioration of wearing surface.

Figure 115. Deterioration described by Note C2 – T-beam deterioration.

Figure 116. Deterioration described by Note C3 – Three-quarter length transverse crack in east abutment.

Figure 117. Deterioration described by Note D1 – Severe deterioration of wearing surface.

Figure 118. Deterioration described by Note D2 – Severe parapet deterioration.

Figure 119. Deterioration described by Note D3 – Longitudinal joint deterioration.

Figure 120. Deterioration described by Note E1 – Severe deterioration of wearing surface.

Figure 121. Deterioration described by Note E2 – Underside deck cracking and/or efflorescence.

Figure 122. Deterioration described by Note E3 – Minor to moderate superstructure corrosion.

Figure 123. Deterioration described by Note E4 – Impact damage to south fascia girder.

Figure 124. Deterioration described by Note G1 – Moderate to severe corrosion of abutment bearings.

Table 124. Task A – Note-taking frequency.

Note	Percentage of Inspectors
A1	67%
A2	82%
A3	65%
A4	61%
A5	24%

Table 125. Task A – Distribution of number of notes taken.

Number of Notes	Frequency
0	1
1	3
2	10
3	18
4	15
5	2

From tables 124 and 125, it can be seen that, with the exception of Note A5 (impact damage to superstructure stiffener), more than half of the inspectors took each note. One possible reason that Note A5 may have been overlooked is that the damage was in the upper half of the girders and the inspector's attention may have been focused more on evaluating the deck than the superstructure. The most common number of notes taken was three. One inspector did not take any of the notes and only two inspectors took all five of the notes.

5.2.5.2.2. Task B

Of the four field notes investigated for Task B, the inspectors took an average of 3.1 notes (standard deviation of 1.0), with a minimum of one and a maximum of four. Table 126 summarizes the frequency with which individual Task B notes were taken and table 127 gives the frequency distribution with which different numbers of Task B notes were taken.

Table 126. Task B – Note-taking frequency.

Note	Percentage of Inspectors
B1	65%
B2	73%
B3	88%
B4	84%

Table 127. Task B – Distribution of number of notes taken.

Number of Notes	Frequency
0	0
1	3
2	12
3	11
4	23

From tables 126 and 127, it can be seen that more than half of the inspectors took each note, with more than 80 percent taking Notes B3 and B4. Although these are relatively high percentages, the severity of the deterioration that would have precipitated each note is such that one would expect nearly all inspectors to have taken each note. As one would expect given the percentage of inspectors taking each note, the most frequent number of notes taken was four. Ninety-four percent of the inspectors took at least two of the notes.

5.2.5.2.3. Task C

Of the three field notes investigated for Task C, inspectors took an average of 2.1 notes (standard deviation of 1.0), with a minimum of zero and a maximum of three. Table 128 summarizes the frequency with which individual Task C notes were taken and table 129 gives the frequency distribution with which different numbers of Task C notes were taken.

Table 128. Task C – Note-taking frequency.

Note	Percentage of Inspectors
C1	69%
C2	76%
C3	67%

Table 129. Task C – Distribution of number of notes taken.

Number of Notes	Frequency
0	3
1	11
2	12
3	23

More than 60 percent of the inspectors took each note. Just as in Task B, given the severity of the deterioration described by each note, one could reasonably argue that nearly all of the inspectors should have taken Notes C1 through C3. Similar to Task B, nearly half of the inspectors took all three notes. However, three inspectors failed to take any of the investigated notes. This lack of any note-taking could be attributed to the fact that the Task B and Task C bridges are very similar.

5.2.5.2.4. Task D

Of the three field notes investigated for Task D, the inspectors took an average of 2.3 notes (standard deviation of 0.8), with a minimum of zero and a maximum of three. Table 130 summarizes the frequency with which individual Task D notes were taken and table 131 gives the frequency distribution with which different numbers of Task D notes were taken.

Table 130. Task D – Note-taking frequency.

Note	Percentage of Inspectors
D1	76%
D2	76%
D3	78%

Table 131. Task D – Distribution of number of notes taken.

Number of Notes	Frequency
0	2
1	6
2	17
3	24

As can be seen from these tables, approximately 75 percent of the inspectors took each note. More than 80 percent of the inspectors took at least two of the notes. Again, although these are relatively high frequencies, the level of deterioration in the elements described by Notes D1 through D3 is so severe that one could expect all inspectors to have noted them.

5.2.5.2.5. Task E

Of the four field notes investigated for Task E, the inspectors took an average of 2.7 notes (standard deviation of 0.8), with a minimum of one and a maximum of four. Table 132 summarizes the frequency with which individual Task E notes were taken and table 133 gives the frequency distribution with which different numbers of Task E notes were taken.

With the exception of noting the impact damage to the south fascia girder (Note E4), more than half of the inspectors took each note. Although the impact damage is quite localized, the ramifications of being hit by an over-height vehicle can be significant and, therefore, a note may be expected.

Table 132. Task E – Note-taking frequency.

Note	Percentage of Inspectors
E1	78%
E2	88%
E3	69%
E4	33%

Table 133. Task E – Distribution of number of notes taken.

Number of Notes	Frequency
0	0
1	3
2	17
3	22
4	7

5.2.5.2.6. Task G

For the one field note investigated for Task G, 34 inspectors took the note and 15 did not. This is approximately 70 percent of the inspectors. It is plausible that, because the bridge is in very good condition overall, localized deficiencies such as the one described by Note G1 could be overlooked.

5.2.5.3. INFLUENCE OF INSPECTOR FACTORS ON NOTE-TAKING

In this section, the relationship between the inspector factors described previously and note-taking will be discussed. This type of analysis is important because some State DOTs may rely heavily on their inspector field notes and less on Condition Ratings for making condition assessments.

Most of the analyses presented in this section are based on the t-test for statistical difference between two samples. Specifically, the goal in applying the t-test here was to determine if inspectors who took a particular note had statistically different inspector factors from those who did not take the note. Table 134 shows the probabilities that the inspectors who took individual notes are not statistically different from those who did not take the individual notes. In other words, low probabilities in table 134 indicate a higher likelihood that the inspector factor may have some correlation with taking the note. The inspector factors summarized in table 134 are the SRQ questions for which inspectors could give a quantitative or scaled response (e.g., on a scale of 1 to 5).

Although some low probabilities are shown in table 134, no clear trends are observed. To supplement the data given in table 134, groups of similar notes were combined to determine whether relationships between similar notes and the inspector factors existed. The similar note groups are summarized in table 135, with the probability data given in table 136. The data in table 136 were developed by averaging the individual probabilities in table 134. As such, these data only give a relative measure of correlation. As before, no clear trends are observed. Five factors had probabilities of less than or equal to 10 percent for at least one of the note categories: Perception of Bridge Inspection Importance to Public Safety, Reported Fear of Heights, Reported Fear of Traffic, Experience in Bridge Inspection, and Comparison to Other Inspectors. An additional six factors had probabilities less than or equal to 20 percent for at least one of the categories: Height, Quality of Relationship With Supervisor, Percentage of Time on Bridge Inspection, Number of Annual Bridge Inspections, General Education Level, and Formal Bridge Inspection Training.

Table 134. Influence of inspector factors on note-taking.

Task	Note	Age	Height	Weight	General Physical Condition	General Mental Condition	Perception of Bridge Importance to Public Safety	General Mental Focus	Interest in Bridge Inspection Work
A	A1	64%	24%	2%	36%	46%	52%	61%	43%
	A2	75%	36%	32%	93%	12%	21%	19%	89%
	A3	64%	87%	19%	41%	56%	4%	55%	62%
	A4	73%	22%	60%	95%	83%	54%	88%	65%
	A5	89%	68%	23%	94%	42%	60%	53%	72%
B	B1	7%	78%	45%	0%	34%	13%	50%	31%
	B2	58%	21%	48%	46%	87%	15%	66%	62%
	B3	21%	47%	46%	76%	34%	25%	4%	89%
	B4	68%	17%	35%	79%	64%	30%	9%	25%
C	C1	52%	91%	83%	20%	36%	75%	22%	3%
	C2	31%	58%	54%	94%	37%	26%	76%	84%
	C3	92%	11%	46%	36%	82%	63%	4%	80%
D	D1	54%	86%	59%	32%	75%	60%	44%	13%
	D2	58%	42%	100%	94%	81%	49%	76%	76%
	D3	89%	86%	57%	7%	21%	34%	54%	21%
E	E1	0%	99%	43%	34%	9%	66%	27%	92%
	E2	94%	48%	65%	27%	34%	5%	68%	55%
	E3	91%	41%	41%	8%	88%	17%	61%	12%
	E4	74%	13%	94%	67%	81%	52%	44%	7%
G	G1	90%	68%	61%	78%	4%	37%	22%	3%

Table 134. Influence of inspector factors on note-taking (continued).

Task	Note	Reported Fear of Heights	Reported Fear of Enclosed Spaces	Reported Fear of Traffic	Experience in Bridge Inspection	Experience in Highway Structures	Estimated Additional Years as a Bridge Inspector	Quality of Relationship With Supervisor	Perceived Importance of Work by Management
A	A1	69%	40%	48%	62%	91%	89%	42%	99%
	A2	10%	75%	21%	68%	26%	34%	25%	67%
	A3	99%	38%	66%	95%	96%	49%	84%	35%
	A4	95%	92%	8%	24%	75%	46%	46%	92%
	A5	46%	61%	2%	2%	35%	6%	14%	87%
B	B1	69%	9%	17%	13%	11%	75%	27%	98%
	B2	93%	96%	15%	60%	75%	21%	18%	84%
	B3	4%	65%	59%	26%	70%	44%	53%	1%
	B4	21%	69%	10%	70%	67%	23%	5%	68%
C	C1	41%	49%	0%	67%	42%	42%	96%	48%
	C2	16%	91%	75%	32%	34%	44%	14%	87%
	C3	69%	53%	10%	24%	20%	66%	1%	51%
D	D1	34%	91%	2%	87%	70%	31%	30%	11%
	D2	34%	13%	18%	67%	56%	40%	97%	11%
	D3	31%	29%	93%	76%	72%	17%	47%	81%
E	E1	56%	86%	93%	12%	24%	17%	47%	18%
	E2	73%	94%	59%	25%	6%	6%	53%	29%
	E3	67%	96%	98%	71%	87%	34%	33%	11%
	E4	44%	8%	8%	8%	31%	85%	8%	53%
G	G1	67%	96%	1%	57%	59%	56%	17%	48%

Table 134. Influence of inspector factors on note-taking (continued).

Task	Note	Percentage Time on Bridge Inspection	Percentage Routine Inspections	Percentage of Inspections With On-Site PE	Comparison to Other Inspectors	Number of Annual Bridge Inspections	General Education Level	Formal Bridge Inspection Training	Jet Lag
A	A1	28%	60%	92%	70%	73%	38%	78%	38%
	A2	81%	72%	84%	23%	85%	29%	90%	45%
	A3	67%	71%	51%	71%	68%	22%	58%	81%
	A4	87%	75%	96%	74%	36%	26%	94%	71%
	A5	48%	74%	48%	48%	21%	59%	37%	55%
B	B1	9%	76%	63%	71%	59%	19%	5%	61%
	B2	8%	30%	57%	23%	53%	34%	61%	24%
	B3	59%	11%	40%	9%	74%	41%	34%	15%
	B4	10%	62%	16%	8%	60%	15%	9%	6%
C	C1	45%	17%	95%	6%	92%	50%	18%	44%
	C2	42%	52%	95%	5%	52%	91%	6%	77%
	C3	96%	93%	81%	100%	56%	18%	78%	78%
D	D1	26%	70%	61%	46%	51%	44%	64%	20%
	D2	23%	39%	5%	34%	31%	27%	49%	20%
	D3	6%	84%	63%	94%	11%	18%	30%	46%
E	E1	83%	9%	92%	34%	80%	92%	71%	23%
	E2	83%	73%	40%	9%	87%	41%	23%	85%
	E3	85%	71%	64%	86%	70%	95%	6%	50%
	E4	37%	67%	67%	67%	13%	75%	43%	79%
G	G1	65%	59%	81%	6%	40%	50%	25%	6%

Table 135. General note categories.

Category	Notes	General Description
GC1	B1, C1, D1, E1	Wearing surface condition
GC2	A1, E2	Underside deck cracking/efflorescence
GC3	B2, D2	Parapet condition
GC4	A3, E3	Corrosion of steel superstructure
GC5	B3, C2	Deterioration of concrete superstructure
GC6	A5, E4	Superstructure impact damage
Deck	A1, B1, B2, C1, D1, D2, E1, E2	All Deck-related notes
Super	A2, A3, A5, B3, C2, D3, E3, E4, G1	All Superstructure-related notes
Sub	A4, B4, C3	All Substructure-related notes
All	A1-A5, B1-B4, C1-C3, D1-D3, E1-E4, G1	All notes

Based on the broad All Notes category, the following factors showed the strongest, although not necessarily statistically significant, relationship with note-taking:

- Fear of Traffic
- Perception of Bridge Inspection Importance to Public Safety
- Quality of Relationship With Supervisor
- Estimated Additional Years as a Bridge Inspector
- Comparison to Other Inspectors
- General Education Level
- Formal Bridge Inspection Training

In addition to the quantitative and scaled SRQ questions presented previously, SRQ questions in which inspectors either answered yes or no, or indicated one of two possible categories, were also analyzed. Unfortunately, the t-test cannot be used to determine statistical significance for these types of questions. In light of this, the following were determined from the analyses of all such SRQ questions and may or may not be statistically significant:

Table 136. Influence of inspector factors on general note-taking.

Note Category	Age	Height	Weight	General Physical Condition	General Mental Condition	Perception of Bridge Importance to Public Safety	General Mental Focus	Interest in Bridge Inspection Work
GC1	28%	89%	57%	22%	38%	53%	36%	35%
GC2	79%	36%	34%	31%	40%	29%	64%	49%
GC3	58%	32%	74%	70%	84%	32%	71%	69%
GC4	78%	64%	30%	24%	72%	10%	58%	37%
GC5	26%	53%	50%	85%	35%	26%	40%	86%
GC6	81%	40%	59%	81%	62%	56%	49%	39%
Deck	48%	61%	56%	36%	50%	42%	52%	47%
Super	69%	56%	48%	62%	42%	31%	43%	49%
Sub	78%	17%	47%	70%	76%	49%	33%	57%
All	62%	52%	51%	53%	50%	38%	45%	49%

Table 136. Influence of inspector factors on general note-taking (continued).

Note Category	Reported Fear of Heights	Reported Fear of Enclosed Spaces	Reported Fear of Traffic	Experience in Bridge Inspection	Experience in Highway Structures	Estimated Additional Years as a Bridge Inspector	Quality of Relationship With Supervisor	Perceived Importance of Work by Management
GC1	50%	59%	28%	45%	37%	41%	50%	43%
GC2	71%	67%	54%	43%	48%	47%	47%	64%
GC3	63%	54%	17%	64%	66%	57%	57%	47%
GC4	83%	67%	82%	83%	92%	58%	58%	23%
GC5	10%	78%	67%	29%	52%	34%	34%	44%
GC6	45%	34%	5%	5%	33%	11%	11%	70%
Deck	59%	60%	32%	49%	47%	51%	51%	50%
Super	43%	62%	47%	48%	57%	33%	33%	52%
Sub	62%	71%	9%	39%	54%	17%	17%	70%
All	52%	62%	35%	47%	52%	38%	38%	54%

Table 136. Influence of inspector factors on general note-taking (continued).

Note Category	Percentage Time on Bridge Inspection	Percentage Routine Inspections	Percent of Inspections With On-Site PE	Comparison to Other Inspectors	Number of Annual Bridge Inspections	General Education Level	Formal Bridge Inspection Training	Jet Lag
GC1	41%	43%	77%	39%	70%	51%	40%	37%
GC2	56%	67%	66%	40%	80%	39%	50%	61%
GC3	16%	35%	31%	28%	42%	30%	55%	22%
GC4	75%	71%	57%	79%	69%	59%	32%	66%
GC5	51%	31%	68%	7%	63%	66%	20%	46%
GC6	43%	70%	58%	58%	17%	67%	40%	67%
Deck	38%	47%	63%	37%	66%	43%	46%	39%
Super	54%	62%	66%	45%	48%	53%	37%	50%
Sub	64%	76%	64%	61%	51%	20%	61%	52%
All	49%	58%	64%	44%	56%	44%	44%	46%

- In general, a larger percentage of the inspectors who did not take notes indicated that they were experiencing additional stress due to personal problems (11.5 percent versus 10.3 percent).
- In general, a larger percentage of the inspectors who did not take notes indicated that they assess the importance of bridge inspection to public safety (96.3 percent versus 93.5 percent).
- In general, a larger percentage of note-taking inspectors indicated that they had worked as an inspector in another industry (27.7 percent versus 21.6 percent).
- In general, a larger percentage of note-taking inspectors indicated that they were taking either bilberry, Viagra, or B vitamin complex (7.8 percent versus 3.9 percent).
- Twenty-nine percent of the note-taking inspectors and 39 percent of the inspectors who did not take notes indicated that their State's inspection philosophy was to comply with the NBIS requirements.
- Seventy-one percent of the note-taking inspectors and 61 percent of the inspectors who did not take notes indicated that their State's inspection philosophy was to identify all defects.

In addition to the inspector factors that were analyzed, one inspection factor was also analyzed. Since the amount of time each inspector was allowed to spend on each task was limited, it was hypothesized that the amount of inspection time used may correlate with note-taking. The results of this analysis indicated that the amount of time spent on each task did not correlate with inspector note-taking.

5.2.5.4. INFLUENCE OF NOTE-TAKING ON PRIMARY ELEMENT CONDITION RATINGS

In this section, the influence of taking specific field inspection notes on the primary element Condition Ratings is presented. The goal of this analysis is to determine whether taking, or not taking, a specific note may influence Condition Ratings. The t-test was used to determine whether inspectors who took notes gave statistically different Condition Ratings than those that did not take notes.

Tables 137 through 142 summarize the probability that the note-taking inspectors and the inspectors who did not take notes did not give statistically different Condition Ratings. As in the previous discussion, no clear trends exist in the data. Furthermore, when one looks at the relationship between notes on a specific element and the Condition Rating for that element (shown in bold in the tables), in all cases except Note D1 and the Deck, no significant relationship existed. From this, one can conclude that taking the notes studied herein had no influence on the assigning of Condition Ratings. However, this does not imply that inspection notes are not valuable.

To supplement the task-by-task analysis, the DFR data were used to combine the Condition Ratings from all tasks. For this analysis, the inspectors were grouped into High and Low General Note-Taking Groups based on the total number of notes taken during all of the tasks ("High" is more than 16 notes and "Low" is fewer than 14 notes out of a possible 20). The average DFR for the two groups was then compared using the t-test for statistical difference with the results given in table 143. From these data, it appears that general note-taking may have

Table 137. Task A – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
A1	**13%**	12%	21%
A2	88%	**68%**	98%
A3	96%	**43%**	83%
A4	1%	54%	**32%**
A5	75%	**52%**	77%

Table 138. Task B – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
B1	**22%**	28%	96%
B2	**86%**	65%	17%
B3	91%	**72%**	69%
B4	22%	37%	**89%**

Table 139. Task C – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
C1	**25%**	26%	72%
C2	71%	**31%**	67%
C3	0.004%	33%	**84%**

Table 140. Task D – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
D1	**1%**	0.3%	5%
D2	**15%**	0.1%	22%
D3	48%	**67%**	**75%**

Table 141. Task E – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
E1	**35%**	48%	99%
E2	**66%**	23%	83%
E3	38%	**81%**	24%
E4	50%	**49%**	88%

Table 142. Task G – Influence of note-taking on Condition Ratings.

	Element		
Note	Deck	Superstructure	Substructure
G1	66%	**31%**	22%

Table 143. Relationship between general note-taking groups and DFR.

Element	General Note-Taking Group				Significance Level
	Low		High		
	Average	Standard Deviation	Average	Standard Deviation	
Deck	0.44	0.79	0.82	0.44	17%
Superstructure	0.23	0.59	0.44	0.47	33%
Substructure	-0.15	0.70	0.09	0.51	12%
All Elements	0.14	0.64	0.41	0.42	24%

some relationship with the DFR data. From these data, it is clear that the High General Note-Taking Group had larger average DFRs with less dispersion, indicating that inspectors who noted more deficiencies gave higher Condition Ratings.

5.2.6. Statistical Analysis of Secondary Bridge Elements

In this section, general statistical information will be presented for Condition Ratings assigned to the secondary bridge elements during the Routine Inspection tasks. In a typical NBIS inspection, Condition Ratings are not assigned to the secondary elements. Rather, these elements are rated differently based on individual State requirements. One inspection model assigns either a G, F, P, or N (good, fair, poor, or not applicable, respectively). The previously described 0 to 9 system used by the inspectors participating in this study may be an abnormal format. In light of this, very little advanced analysis was completed on these data, and the results are presented to illustrate three trends within the data: (1) the distribution of the Condition Ratings that were assigned; (2) the differences in the State definitions of the secondary elements; and (3) the secondary elements that generally control the primary element Condition Ratings. As in previous discussions, the results are presented in a task-by-task format.

5.2.6.1. TASK A

Tables 144 through 146 summarize the assigned Condition Ratings for Task A. Note from table 144 that 46 or fewer inspectors gave Condition Ratings for each of the secondary elements, whereas 49 inspectors gave an overall Condition Rating for the deck (average of 5.8, standard deviation of 0.81). From table 144, it appears that condition assessments from the wearing surface, deck underside, and curbs are the controlling secondary elements for the overall deck

Table 144. Task A – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	5.8	5.2	6.0	N/A*	5.7	5.0	5.0	6.3	5.6	5.3	6.0	N/A	N/A
Standard Deviation	1.23	0.95	0.73	N/A	1.03	1.41	0.82	0.49	0.51	1.02	1.00	N/A	N/A
COV	0.21	0.18	0.12	N/A	0.18	0.28	0.16	0.08	0.09	0.19	0.17	N/A	N/A
Minimum	4	4	4	N/A	3	4	4	6	5	3	5	N/A	N/A
Maximum	8	7	7	N/A	8	6	6	7	6	8	7	N/A	N/A
Mode	6	5	6	N/A	6	N/A	5	6	6	5	7	N/A	N/A
N	23	23	46	N/A	46	2	4	7	12	34	5	N/A	N/A

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A
1	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A
2	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A
3	0	0	0	N/A	1	0	0	0	0	2	0	N/A	N/A
4	5	6	1	N/A	4	1	1	0	0	4	0	N/A	N/A
5	3	8	9	N/A	15	0	2	0	5	14	2	N/A	N/A
6	7	7	25	N/A	16	1	1	5	7	12	1	N/A	N/A
7	7	2	11	N/A	9	0	0	2	0	1	2	N/A	N/A
8	1	0	0	N/A	1	0	0	0	0	1	0	N/A	N/A
9	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A

Note: Average overall deck Condition Rating = 5.8.
* N/A = Not applicable.

Table 145. Task A – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	5.8	5.8	5.3	N/A*	6.2	N/A	3.0	5.5	6.1	6.4	6.7
Standard Deviation	0.96	0.77	0.89	N/A	0.78	N/A	N/A	1.15	1.22	0.90	0.76
COV	0.17	0.13	0.17	N/A	0.13	N/A	N/A	0.21	0.20	0.14	0.11
Minimum	5	4	4	N/A	5	N/A	3	3	1	4	6
Maximum	7	7	7	N/A	8	N/A	3	8	8	8	8
Mode	5	6	5	N/A	6	N/A	3	6	6	7	7
N	4	39	8	N/A	47	N/A	1	46	44	30	7

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	0	0	0	N/A	0	N/A	0	0	0	0	0
1	0	0	0	N/A	0	N/A	0	0	1	0	0
2	0	0	0	N/A	0	N/A	0	0	0	0	0
3	0	0	0	N/A	0	N/A	1	2	0	0	0
4	0	1	1	N/A	0	N/A	0	7	2	1	0
5	2	13	5	N/A	8	N/A	0	14	6	3	0
6	1	18	1	N/A	23	N/A	0	14	19	10	3
7	1	7	1	N/A	14	N/A	0	8	13	14	3
8	0	0	0	N/A	2	N/A	0	1	3	2	1
9	0	0	0	N/A	0	N/A	0	0	0	0	0

Note: Average overall superstructure Condition Rating = 5.9.
* N/A = Not applicable.

Table 146. Task A – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	6.0	8.0	6.0	6.1	6.5	6.2	6.9	N/A*	N/A	N/A	7.0	6.5
Standard Deviation	0.73	N/A	N/A	0.77	0.93	0.73	0.81	N/A	N/A	N/A	N/A	0.71
COV	0.12	N/A	N/A	0.13	0.14	0.12	0.12	N/A	N/A	N/A	N/A	0.11
Minimum	5	8	6	5	4	4	5	N/A	N/A	N/A	7	6
Maximum	7	8	6	7	8	7	8	N/A	N/A	N/A	7	7
Mode	6	8	6	6	7	6	7	N/A	N/A	N/A	7	6,7
N	33	1	1	16	44	45	48	N/A	N/A	N/A	1	2

	Frequency											
Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	0
1	0	0	0	0	0	0	0	N/A	N/A	N/A	0	0
2	0	0	0	0	0	0	0	N/A	N/A	N/A	0	0
3	0	0	0	0	0	0	0	N/A	N/A	N/A	0	0
4	0	0	0	0	1	1	0	N/A	N/A	N/A	0	0
5	8	0	0	4	5	5	2	N/A	N/A	N/A	0	0
6	16	0	1	7	15	23	11	N/A	N/A	N/A	0	1
7	9	0	0	5	18	16	23	N/A	N/A	N/A	1	1
8	0	1	0	0	5	0	12	N/A	N/A	N/A	0	0
9	0	0	0	0	0	0	0	N/A	N/A	N/A	0	0

Note: Average overall substructure Condition Rating = 6.1.
* N/A = Not applicable.

Condition Rating. Note that 23 inspectors assigned Condition Ratings for the deck topside, even though less than 5 percent of the deck surface was visible. From table 145, it is apparent that the condition of the floor beams and girders/stringers controls the overall superstructure Condition Rating (average of 5.9, standard deviation of 0.78). However, there appears to be some confusion in the definitions of the bridge element types (e.g., girders vs. stringers, floor beams vs. floor system bracing, etc.). The data in table 146 indicate that inspectors may be basing their overall substructure Condition Ratings (average of 6.1, standard deviation of 0.79) on assessments of the abutments and the bearing seat. Finally, note that one inspector gave a Condition Rating for column/stem even though this bridge had no intermediate piers.

5.2.6.2. TASK B

Tables 147 through 149 summarize the assigned Condition Ratings for Task B. Similar to Task A, the wearing surface and deck underside were the most commonly rated secondary elements. Interestingly, one inspector rated stay-in-place (SIP) forms and two rated sidewalks, despite the fact that they did not exist on Bridge B101A. As before, there appears to be some confusion in the classification of the superstructure elements. Most inspectors classified the superstructure as multibeam followed by girder and stringer. Two inspectors rated floor beams when none existed. From the data in table 149, the overall assessment of the substructure (average of 4.3, standard deviation of 0.76) is controlled by the abutment conditions. As in Task A, one inspector rated substructure elements that did not exist (e.g., piers and bents).

5.2.6.3. TASK C

Tables 150 through 152 summarize the assigned Condition Ratings for Task C. Since the Task B and Task C bridges are very similar, it is not surprising that the trends discussed above are repeated for the Task C secondary elements.

5.2.6.4. TASK D

Tables 153 through 155 summarize the assigned Condition Ratings for Task D. From the data in

Table 147. Task B – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	4.0	4.6	5.2	3.0	4.0	4.5	5.5	3.7	3.4	3.4	4.7	N/A*	N/A
Standard Deviation	0.81	1.04	0.87	N/A	0.80	0.88	0.71	0.90	0.74	1.14	2.08	N/A	N/A
COV	0.20	0.23	0.17	N/A	0.20	0.19	0.13	0.24	0.22	0.34	0.45	N/A	N/A
Minimum	2	3	2	3	3	3	5	2	2	2	3	N/A	N/A
Maximum	6	7	7	3	6	6	6	6	5	5	7	N/A	N/A
Mode	4	4	5	3	4	4	5,6	4	3	3	3,4,7	N/A	N/A
N	44	18	46	1	21	13	2	21	35	5	3	N/A	N/A

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A
1	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A
2	1	0	1	0	0	0	0	1	3	1	0	N/A	N/A
3	8	2	0	1	6	1	0	8	17	2	1	N/A	N/A
4	25	8	5	0	11	6	0	9	13	1	1	N/A	N/A
5	8	5	28	0	3	4	1	2	2	1	0	N/A	N/A
6	2	2	9	0	1	2	1	1	0	0	0	N/A	N/A
7	0	1	3	0	0	0	0	0	0	0	1	N/A	N/A
8	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A
9	0	0	0	0	0	0	0	0	0	0	0	N/A	N/A

Note: Average overall deck Condition Rating = 4.9.
* N/A = Not applicable.

Table 148. Task B – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	4.2	3.0	4.0	4.3	4.2	N/A*	N/A	N/A	N/A	N/A	N/A
Standard Deviation	0.44	1.41	N/A	0.85	0.68	N/A	N/A	N/A	N/A	N/A	N/A
COV	0.10	0.47	N/A	0.20	0.16	N/A	N/A	N/A	N/A	N/A	N/A
Minimum	4	2	4	3	3	N/A	N/A	N/A	N/A	N/A	N/A
Maximum	5	4	4	6	5	N/A	N/A	N/A	N/A	N/A	N/A
Mode	4	2,4	4	4	4	N/A	N/A	N/A	N/A	N/A	N/A
N	9	2	1	20	15	N/A	N/A	N/A	N/A	N/A	N/A

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
1	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
2	0	1	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
3	0	0	0	4	2	N/A	N/A	N/A	N/A	N/A	N/A
4	7	1	1	8	8	N/A	N/A	N/A	N/A	N/A	N/A
5	2	0	0	7	5	N/A	N/A	N/A	N/A	N/A	N/A
6	0	0	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A
7	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
8	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
9	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A

Note: Average overall superstructure Condition Rating = 4.2.
* N/A = Not applicable.

Table 149. Task B – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	4.1	6.0	5.9	4.4	4.7	4.5	5.2	5.0	N/A*	8.0	5.0	N/A
Standard Deviation	0.68	0.00	0.64	0.86	0.99	0.87	1.01	N/A	N/A	N/A	N/A	N/A
COV	0.16	0.00	0.11	0.20	0.21	0.19	0.19	N/A	N/A	N/A	N/A	N/A
Minimum	3	6	5	3	4	3	3	5	N/A	8	5	N/A
Maximum	6	6	7	6	7	6	8	5	N/A	8	5	N/A
Mode	4	6	6	5	4	4	5	5	N/A	8	5	N/A
N	36	2	18	17	17	25	47	1	N/A	1	1	N/A

	Frequency											
Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	0	0	0	0	0	0	0	N/A	0	0	N/A
1	0	0	0	0	0	0	0	0	N/A	0	0	N/A
2	0	0	0	0	0	0	0	0	N/A	0	0	N/A
3	5	0	0	3	0	3	1	0	N/A	0	0	N/A
4	22	0	0	6	10	10	11	0	N/A	0	0	N/A
5	8	0	4	7	3	9	19	1	N/A	0	1	N/A
6	1	2	11	1	3	3	12	0	N/A	0	0	N/A
7	0	0	3	0	1	0	3	0	N/A	0	0	N/A
8	0	0	0	0	0	0	1	0	N/A	1	0	N/A
9	0	0	0	0	0	0	0	0	N/A	0	0	N/A

Note: Average overall substructure Condition Rating = 4.3.
* N/A = Not applicable.

Table 150. Task C – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	3.7	4.5	5.3	5.0	5.2	4.6	N/A*	5.8	6.2	4.1	6.0	N/A	N/A
Standard Deviation	0.91	0.89	0.98	N/A	0.90	1.01	N/A	1.30	0.82	1.27	1.73	N/A	N/A
COV	0.24	0.20	0.19	N/A	0.17	0.22	N/A	0.65	0.13	0.31	0.29	N/A	N/A
Minimum	2	3	3	5	3	3	N/A	2	5	3	4	N/A	N/A
Maximum	6	6	7	5	7	6	N/A	8	8	6	7	N/A	N/A
Mode	4	4	6	5	5	4	N/A	5	6	3	7	N/A	N/A
N	46	16	40	1	25	9	N/A	19	35	9	3	N/A	N/A

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	0	0	0	N/A	0	0	0	0	N/A	N/A
1	0	0	0	0	0	0	N/A	0	0	0	0	N/A	N/A
2	3	0	0	0	0	0	N/A	1	0	0	0	N/A	N/A
3	15	1	1	0	1	1	N/A	0	0	4	0	N/A	N/A
4	21	9	9	0	4	4	N/A	0	0	2	1	N/A	N/A
5	5	3	12	1	11	2	N/A	6	8	1	0	N/A	N/A
6	2	3	15	0	8	2	N/A	6	14	2	0	N/A	N/A
7	0	0	3	0	1	0	N/A	5	12	0	2	N/A	N/A
8	0	0	0	0	0	0	N/A	1	1	0	0	N/A	N/A
9	0	0	0	0	0	0	N/A	0	0	0	0	N/A	N/A

Note: Average overall deck Condition Rating = 5.2.
* N/A = Not applicable.

Table 151. Task C – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	4.8	3.0	6.0	4.7	4.7	N/A*	N/A	N/A	N/A	N/A	N/A
Standard Deviation	0.41	1.41	N/A	0.91	0.69	N/A	N/A	N/A	N/A	N/A	N/A
COV	0.10	0.47	N/A	0.20	0.15	N/A	N/A	N/A	N/A	N/A	N/A
Minimum	4	2	6	3	4	N/A	N/A	N/A	N/A	N/A	N/A
Maximum	5	4	6	6	6	N/A	N/A	N/A	N/A	N/A	N/A
Mode	5	2,4	6	5	4,5	N/A	N/A	N/A	N/A	N/A	N/A
N	6	2	1	21	18	N/A	N/A	N/A	N/A	N/A	N/A

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
1	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
2	0	1	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
3	0	0	0	2	0	N/A	N/A	N/A	N/A	N/A	N/A
4	1	1	0	7	8	N/A	N/A	N/A	N/A	N/A	N/A
5	5	0	0	8	8	N/A	N/A	N/A	N/A	N/A	N/A
6	0	0	1	4	2	N/A	N/A	N/A	N/A	N/A	N/A
7	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
8	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
9	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A

Note: Average overall superstructure Condition Rating = 4.6.
* N/A = Not applicable.

Table 152. Task C – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	5.4	N/A*	5.3	5.3	6.1	5.6	6.0	N/A	N/A	6.0	N/A	N/A
Standard Deviation	0.80	N/A	0.82	0.91	0.94	0.71	0.81	N/A	N/A	1.41	N/A	N/A
COV	0.15	N/A	0.15	0.17	0.15	0.13	0.13	N/A	N/A	0.24	N/A	N/A
Minimum	4	N/A	3	4	4	4	4	N/A	N/A	5	N/A	N/A
Maximum	7	N/A	6	7	7	7	8	N/A	N/A	7	N/A	N/A
Mode	5	N/A	6	5	6	5	6	N/A	N/A	5,7	N/A	N/A
N	37	N/A	19	14	11	25	45	N/A	N/A	2	N/A	N/A

Frequency

Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
1	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
2	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
3	0	N/A	1	0	0	0	0	N/A	N/A	0	N/A	N/A
4	4	N/A	1	3	1	1	1	N/A	N/A	0	N/A	N/A
5	17	N/A	8	5	1	11	10	N/A	N/A	1	N/A	N/A
6	13	N/A	9	5	5	11	22	N/A	N/A	0	N/A	N/A
7	3	N/A	0	1	4	2	11	N/A	N/A	1	N/A	N/A
8	0	N/A	0	0	0	0	1	N/A	N/A	0	N/A	N/A
9	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A

Note: Average overall substructure Condition Rating = 5.5.
* N/A = Not applicable.

Table 153. Task D – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	3.8	4.6	5.1	N/A*	4.9	4.3	N/A	3.9	3.5	4.0	3.8	N/A	N/A
Standard Deviation	0.86	1.09	0.82	N/A	1.01	0.71	N/A	0.94	0.78	1.66	0.96	N/A	N/A
COV	0.23	0.24	0.16	N/A	0.21	0.16	N/A	0.16	0.22	0.41	0.26	N/A	N/A
Minimum	2	3	3	N/A	3	4	N/A	3	2	1	3	N/A	N/A
Maximum	6	6	6	N/A	7	6	N/A	6	5	7	5	N/A	N/A
Mode	4	4	5	N/A	4	4	N/A	4	4	4	3	N/A	N/A
N	44	16	39	N/A	29	9	N/A	22	30	9	4	N/A	N/A

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	N/A	0	0	N/A	0	0	0	0	N/A	N/A
1	0	0	0	N/A	0	0	N/A	0	0	1	0	N/A	N/A
2	2	0	0	N/A	0	0	N/A	0	3	0	0	N/A	N/A
3	14	3	1	N/A	1	0	N/A	9	11	2	2	N/A	N/A
4	22	5	8	N/A	11	7	N/A	9	14	3	1	N/A	N/A
5	4	4	16	N/A	9	1	N/A	2	2	2	1	N/A	N/A
6	2	4	14	N/A	6	1	N/A	2	0	0	0	N/A	N/A
7	0	0	0	N/A	2	0	N/A	0	0	1	0	N/A	N/A
8	0	0	0	N/A	0	0	N/A	0	0	0	0	N/A	N/A
9	0	0	0	N/A	0	0	N/A	0	0	0	0	N/A	N/A

Note: Average overall deck Condition Rating = 4.8.
* N/A = Not applicable.

Table 154. Task D – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	N/A*	N/A	N/A	N/A	N/A	5.4	N/A	N/A	N/A	N/A	N/A
Standard Deviation	N/A	N/A	N/A	N/A	N/A	1.00	N/A	N/A	N/A	N/A	N/A
COV	N/A	N/A	N/A	N/A	N/A	0.19	N/A	N/A	N/A	N/A	N/A
Minimum	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	N/A
Maximum	N/A	N/A	N/A	N/A	N/A	7	N/A	N/A	N/A	N/A	N/A
Mode	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	N/A
N	N/A	N/A	N/A	N/A	N/A	17	N/A	N/A	N/A	N/A	N/A

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
1	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	N/A
7	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
9	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A

Note: Average overall superstructure Condition Rating = 5.3.

* N/A = Not applicable.

Table 155. Task D – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	6.1	N/A*	6.1	6.1	6.0	6.4	5.9	N/A	N/A	8.0	N/A	N/A
Standard Deviation	0.84	N/A	0.80	0.49	1.00	0.88	1.04	N/A	N/A	N/A	N/A	N/A
COV	0.14	N/A	0.13	0.08	0.17	0.14	0.18	N/A	N/A	N/A	N/A	N/A
Minimum	4	N/A	5	5	5	5	4	N/A	N/A	8	N/A	N/A
Maximum	8	N/A	7	7	7	8	8	N/A	N/A	8	N/A	N/A
Mode	6	N/A	6	6	5,6,7	6	6	N/A	N/A	8	N/A	N/A
N	32	N/A	15	13	3	9	35	N/A	N/A	1	N/A	N/A

	Frequency											
Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
1	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
2	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
3	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A
4	1	N/A	0	0	0	0	3	N/A	N/A	0	N/A	N/A
5	6	N/A	4	1	1	1	9	N/A	N/A	0	N/A	N/A
6	16	N/A	6	10	1	4	13	N/A	N/A	0	N/A	N/A
7	8	N/A	5	2	1	3	8	N/A	N/A	0	N/A	N/A
8	1	N/A	0	0	0	1	2	N/A	N/A	1	N/A	N/A
9	0	N/A	0	0	0	0	0	N/A	N/A	0	N/A	N/A

Note: Average overall substructure Condition Rating = 6.1.
* N/A = Not applicable.

table 153, it appears as though the inspectors primarily used assessments of the wearing surface, deck topside, and deck underside to establish the overall deck Condition Rating (average of 4.8, standard deviation of 0.94). The only secondary superstructure element to be given a rating was "arches". As with the other tasks, the abutments were the primary secondary elements controlling the overall substructure Condition Rating (average of 6.1, standard deviation of 0.89). Finally, one inspector rated pier footings even though no piers existed.

5.2.6.5. TASK E

Tables 156 through 158 summarize the assigned Condition Ratings for Task E. The trends for Task E are similar to those already discussed. One inspector rated arches even though none existed (although some of the floor beams are curved). As in the previous tasks, one inspector rated piers and bents even though none existed.

5.2.6.6. TASK G

Tables 159 through 161 summarize the assigned Condition Ratings for Task G. It appears that most inspectors may have assigned their overall deck Condition Rating (average of 7.1, standard deviation of 0.53) based on the deck underside condition. The 49 inspectors rated the expansion joint on the Route 1 Bridge with considerable spread in the Condition Ratings (from 3 to 8). It should be pointed out that the expansion joint was recently replaced and one could therefore conclude that it could have been rated a 9. There was again some confusion in the secondary element definitions for Task G. Thirty-eight inspectors used the girders secondary element with another 8 and 3 using multibeams and stringers, respectively. Inspectors using the girders secondary element gave the highest ratings. Unlike the previous tasks, no clear trends exist in the substructure secondary element Condition Ratings.

Table 156. Task E – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	3.6	4.3	4.6	N/A*	3.9	4.3	5.0	4.6	4.8	4.2	4.5	N/A	N/A
Standard Deviation	0.86	0.86	0.76	N/A	0.69	0.73	1.41	0.88	0.87	1.28	1.73	N/A	N/A
COV	0.24	0.20	0.16	N/A	0.18	0.17	0.28	0.19	0.18	0.30	0.38	N/A	N/A
Minimum	1	3	3	N/A	3	3	4	3	3	1	3	N/A	N/A
Maximum	6	6	6	N/A	5	6	6	6	6	7	7	N/A	N/A
Mode	4	4	5	N/A	4	4	4,6	4	5	5	4	N/A	N/A
N	46	20	47	N/A	29	14	2	28	34	33	4	N/A	N/A

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A
1	1	0	0	N/A	0	0	0	0	0	1	0	N/A	N/A
2	3	0	0	N/A	0	0	0	0	0	1	0	N/A	N/A
3	15	3	3	N/A	9	1	0	2	2	7	1	N/A	N/A
4	24	10	16	N/A	15	9	1	13	10	9	2	N/A	N/A
5	2	5	23	N/A	5	3	0	8	14	12	0	N/A	N/A
6	1	2	5	N/A	0	1	1	5	8	1	0	N/A	N/A
7	0	0	0	N/A	0	0	0	0	0	2	1	N/A	N/A
8	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A
9	0	0	0	N/A	0	0	0	0	0	0	0	N/A	N/A

Note: Average overall deck Condition Rating = 4.5.
* N/A = Not applicable.

Table 157. Task E – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	5.8	6.0	6.1	5.7	5.9	6.0	N/A*	5.1	5.4	5.9	6.6
Standard Deviation	0.97	0.69	0.68	0.82	0.69	N/A	N/A	1.05	0.86	0.97	0.88
COV	0.17	0.11	0.11	0.14	0.12	N/A	N/A	0.21	0.16	0.16	0.13
Minimum	4	5	5	5	5	6	N/A	3	2	4	5
Maximum	7	7	7	7	7	6	N/A	8	7	7	8
Mode	5	6	6	5	6	6	N/A	5	5	6	7
N	14	28	18	6	35	1	N/A	43	45	35	9

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	0	0	0	0	0	0	N/A	0	0	0	0
1	0	0	0	0	0	0	N/A	0	0	0	0
2	0	0	0	0	0	0	N/A	0	1	0	0
3	0	0	0	0	0	0	N/A	4	0	0	0
4	1	0	0	0	0	0	N/A	4	2	3	0
5	5	6	3	3	11	0	N/A	22	22	8	1
6	4	15	10	2	18	1	N/A	10	17	12	3
7	4	7	5	1	6	0	N/A	2	3	12	4
8	0	0	0	0	0	0	N/A	1	0	0	1
9	0	0	0	0	0	0	N/A	0	0	0	0

Note: Average overall superstructure Condition Rating = 5.8.
* N/A = Not applicable.

Table 158. Task E – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	5.2	5.0	5.7	5.4	4.8	5.6	5.6	5.0	N/A*	N/A	6.0	5.4
Standard Deviation	0.72	0.00	0.58	1.09	0.96	0.97	0.98	N/A	N/A	N/A	N/A	0.89
COV	0.14	0.00	0.10	0.20	0.20	0.17	0.17	N/A	N/A	N/A	N/A	0.17
Minimum	4	5	5	3	3	4	4	5	N/A	N/A	6	5
Maximum	7	5	6	7	7	8	7	5	N/A	N/A	6	7
Mode	5	5	6	5	5	6	6	5	N/A	N/A	6	5
N	37	2	3	16	46	39	46	1	N/A	N/A	1	5

	Frequency											
Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	0	0	0	0	0	0	0	N/A	N/A	0	0
1	0	0	0	0	0	0	0	0	N/A	N/A	0	0
2	0	0	0	0	0	0	0	0	N/A	N/A	0	0
3	0	0	0	1	3	0	0	0	N/A	N/A	0	0
4	4	0	0	1	15	5	7	0	N/A	N/A	0	0
5	22	2	1	7	20	13	13	1	N/A	N/A	0	4
6	9	0	2	4	5	15	17	0	N/A	N/A	1	0
7	2	0	0	3	3	5	9	0	N/A	N/A	0	1
8	0	0	0	0	0	1	0	0	N/A	N/A	0	0
9	0	0	0	0	0	0	0	0	N/A	N/A	0	0

Note: Average overall substructure Condition Rating = 5.3.
* N/A = Not applicable.

Table 159. Task G – Deck secondary element Condition Rating statistical information.

	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
Average	7.5	7.4	7.1	N/A*	7.4	7.0	N/A	7.4	7.4	6.9	7.0	7.0	7.3
Standard Deviation	0.59	0.55	0.55	N/A	0.53	N/A	N/A	0.57	0.57	1.09	0.91	N/A	0.88
COV	0.08	0.07	0.08	N/A	0.07	N/A	N/A	0.08	0.08	0.16	0.13	N/A	0.12
Minimum	6	6	6	N/A	7	7	N/A	6	6	3	5	7	5
Maximum	9	8	8	N/A	8	7	N/A	8	8	8	8	7	8
Mode	7	7	7	N/A	7	5	N/A	7	7	7	7	7	8
N	45	35	46	N/A	9	1	N/A	25	46	49	42	1	29

	Frequency												
Condition Rating	Wearing Surface	Deck-topside	Deck-underside	SIP Forms	Curbs	Medians	Sidewalks	Parapets	Railing	Expansion Joints	Drainage System	Lighting	Utilities
0	0	0	0	N/A	0	0	N/A	0	0	0	0	0	0
1	0	0	0	N/A	0	0	N/A	0	0	0	0	0	0
2	0	0	0	N/A	0	0	N/A	0	0	0	0	0	0
3	0	0	0	N/A	0	0	N/A	0	0	1	0	0	0
4	0	0	0	N/A	0	0	N/A	0	0	1	0	0	0
5	0	0	0	N/A	0	7	N/A	0	0	3	4	0	2
6	1	1	5	N/A	0	0	N/A	1	2	7	4	0	2
7	22	20	32	N/A	5	1	N/A	14	25	24	20	1	11
8	21	14	9	N/A	4	0	N/A	10	19	13	14	0	14
9	1	0	0	N/A	0	0	N/A	0	0	0	0	0	0

Note: Average overall deck Condition Rating = 7.1.
* N/A = Not applicable.

Table 160. Task G – Superstructure secondary element Condition Rating statistical information.

	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
Average	6.3	7.3	7.0	6.5	6.8	7.0	N/A*	6.1	5.8	7.0	6.9
Standard Deviation	1.15	0.58	0.47	0.53	0.66	N/A	N/A	0.82	1.00	0.74	0.99
COV	0.18	0.08	0.07	0.08	0.10	N/A	N/A	0.13	0.17	0.11	0.14
Minimum	5	7	6	6	5	7	N/A	4	4	5	4
Maximum	7	8	8	7	8	7	N/A	7	8	8	8
Mode	7	7	7	6	7	7	N/A	6	6	7	7
N	3	3	19	8	38	1	N/A	45	47	41	39

	Frequency										
Condition Rating	Stringers	Floor Beams	Floor System Bracing	Multibeams	Girders	Arches	Cables	Paint	Bearing Devices	Connections	Welds
0	0	0	0	0	0	0	N/A	0	0	0	0
1	0	0	0	0	0	0	N/A	0	0	0	0
2	0	0	0	0	0	0	N/A	0	0	0	0
3	0	0	0	0	0	0	N/A	0	0	0	0
4	0	0	0	0	0	0	N/A	1	4	0	2
5	1	0	0	0	2	0	N/A	10	14	1	0
6	0	0	2	4	7	0	N/A	18	20	8	9
7	2	2	15	4	26	1	N/A	16	6	22	17
8	0	1	2	0	3	0	N/A	0	3	10	11
9	0	0	0	0	0	0	N/A	0	0	0	0

Note: Average overall superstructure Condition Rating = 6.7.
* N/A = Not applicable.

Table 161. Task G – Substructure secondary element Condition Rating statistical information.

	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
Average	7.2	7.0	7.0	7.4	7.2	7.1	7.2	7.4	7.0	7.5	7.5	7.2
Standard Deviation	0.74	N/A*	1.00	0.67	0.66	0.62	0.75	0.62	0.00	0.71	0.59	0.64
COV	0.10	N/A	0.14	0.09	0.09	0.09	0.10	0.08	0.00	0.09	0.08	0.09
Minimum	5	7	6	6	6	6	5	6	7	7	6	6
Maximum	8	7	8	8	8	8	8	8	7	8	8	8
Mode	7	7	6,7,8	7	7	7	7	7	7	7,8	8	7
N	32	1	3	11	40	38	33	30	3	2	42	45

	Frequency											
Condition Rating	Abutments	Piles	Footing	Stem	Bearing Seat	Backwall	Wingwalls	Piers and Bents	Piles	Footing	Columns/Stem	Cap
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	1	0	0	0	0	0	1	0	0	0	0	0
6	3	0	1	1	5	5	3	2	0	0	2	5
7	17	1	1	5	21	23	16	14	3	1	18	25
8	11	0	1	5	14	10	13	14	0	1	22	15
9	0	0	0	0	0	0	0	0	0	0	0	0

Note: Average overall substructure Condition Rating = 7.2.
* N/A = Not applicable.